Bear Den Landing

Creating Resilient Environments & Tribal Communities Through
Ecological Planning & Public Participation on Fort Berthold Reservation

a design thesis by **Morgan Kollman**

BEAR DEN LANDING

Creating Resilient Environments & Tribal Communities
Through Ecological Planning & Public Participation
on Fort Berthold Reservation

A Design Thesis Submitted to the
Department of Architecture and Landscape Architecture
of North Dakota State University

By Morgan Kollman

In Partial Fulfillment of the Requirements
for the Degree of
Master of Landscape Architecture

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THESIS ARCHIVAL NOTE

The following thesis project, entitled (BEAR DEN LANDING: CREATING RESILIENT ENVIRONMENTS & TRIBAL COMMUNITIES THROUGH ECOLOGICAL PLANNING AND PUBLIC PARTICIPATION ON FORT BERTHOLD RESERVATION) was composed over the course of the 2018-2019 academic school year. The Thesis Program, as contained here, was initiated and completed in the fall semester as a part of the LA 763: Programming and Thesis Preparation course. Supplemental material, including the Thesis Boards and the Thesis Presentation documents, were generated in the spring semester as a part of the LA 772: Design Thesis studio. Any inconsistencies between the different documents, in terms of research and design, should be excused per the evolution of the project across the two semesters.

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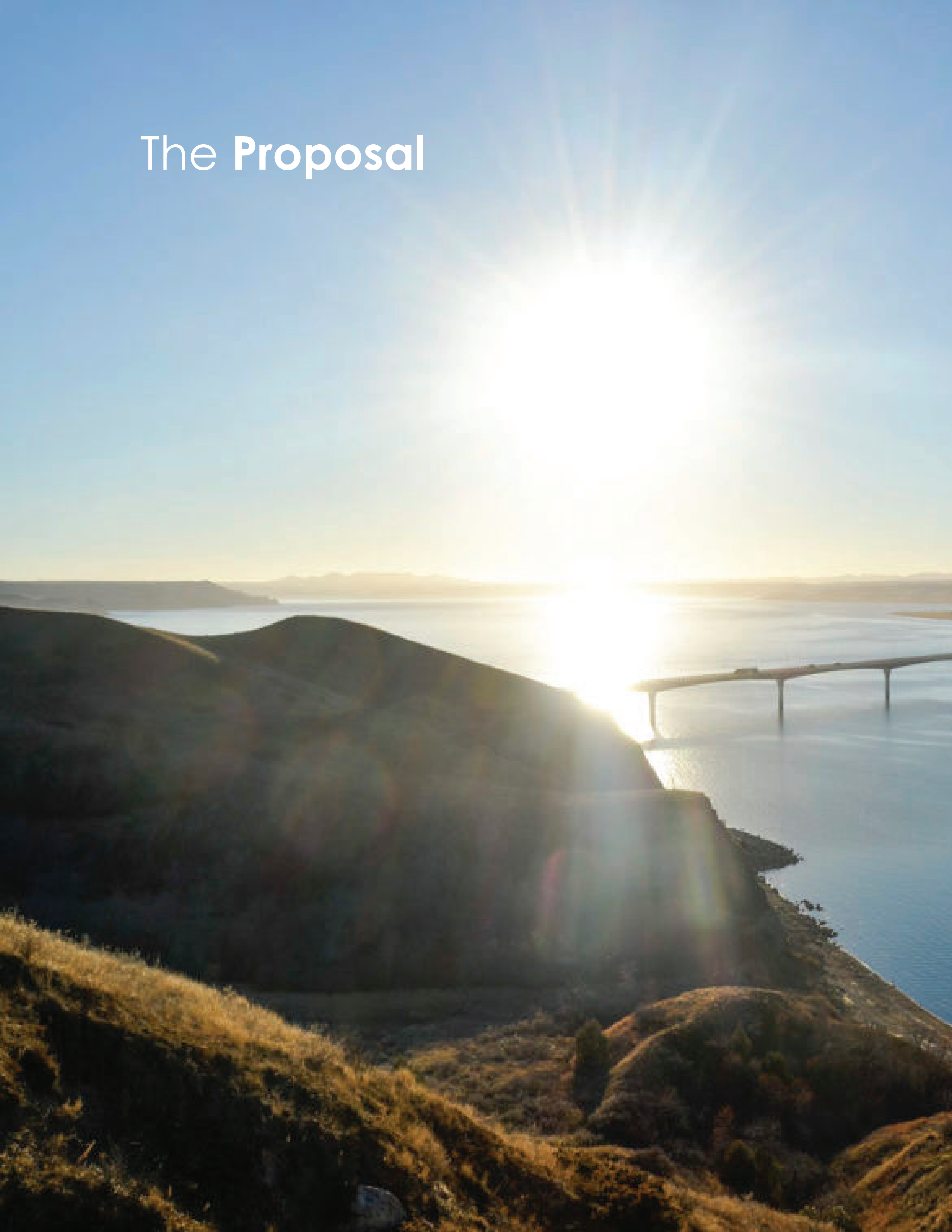
The **Proposal**



"There is a word for land; Eloheh. This same word also means history, culture and religion. We cannot separate our place on earth from our lives on the earth nor from our vision nor our meaning as a people."

-Peter Mathiessen

thesis **abstract:**

Over half of the 135,000 miles of oil and gasoline pipelines in the U.S. were installed before 1969, with implementation of pipes occurring before maturation of steel or coating technology. Leaks and spills are becoming increasingly common within the realm of man-made environmental hazards. North Dakota is the second largest in oil production, suffering from 85 paramount oil spills in last 20 years. North Dakota tribal lands are faced with declining environmental issues as a majority of reservations located in areas of hazard, creating a state of crisis within their livable environment. A broken pipeline burst more than a million gallons of saltwater into Charbonneau Creek, a tributary of the Yellowstone River, causing massive die-off of fish, plants and the tainting of productive soil and drinkable water sources. Most spill damage directly effects Native Americans, who are most reliant on environmental health and stability.

Oil spills are extremely unpredictable, with little available information of when, where and how they occur. Beyond this, there are no remediation or planning strategies to be executed when these spills transpire. While most literature focuses on reports of spills, this study will propose an analytical strategy to mitigate the environmental threat of oil spills to water resources through environmental planning. Geospatial and hydraulic modeling tools will be introduced using National Hydrography Dataset for watershed-based drainage delineations, basin characteristic visualization, and streamflow estimation. A variety of case studies will be examined and analyzed to inform environmental intervention. The result will present a landscape conservation and resiliency plan to include hazard identification, vulnerability analysis and ecological planning for an endangered watershed area on Fort Berthold Reservation near Mandaree, ND. The goal is to provide new perspectives on possibilities of creating a more resilient and sustainable tribal community.

The design of this thesis will focus on the study of the historically rich ecosystem of the river and detrimental effects on Lake Sakakawea and Three Affliated Tribes way of life. Through environmental planning and reclamation, this project seeks to revive the relationship between biological and cultural diversity among natural environments.

thesis **narrative:**

Premise for Investigation

Spiritual, cultural and geographic ties have been cut. Tribe populations, the quality of ecosystem services have all been severely diminished. Native Americans in the United States have been oppressed for hundreds of years, constantly confined within borders or forced to create a lifestyle in urban space away from tradition and customs. Reservations contain nearly $1.5 trillion worth of the nation's natural resources, yet the two million natives in the United States have the highest rate of poverty of any racial group. The disintegration of tribal voice on industrialization has resulted in abuse to the natural environment.

Increased government interference on tribal lands has become harmful to tradition. Multi-million-dollar industries undermine Native American culture, removing the strong ties between the natural landscape and spiritual values. Reparation and sensitivity are two factors that have been far overlooked. The land that was once flourishing with sacred customs is the same land that is now infested with contaminants, revealing adverse environmental and cultural effects. Countless generations have been intoxicated through industrial invasion. The super-fund site of Portland Harbor, the spilling of the Dakota Access Pipeline and the discharge of PCBs in the St. Lawrence River have negatively impacted Native American lands and populations as well as the livelihood of natural ecosystems.

The resistance to coexistence has led to a number of ongoing environmental issues; decreased water quality, contamination of viable soils, and loss of wildlife valuable for biological and cultural diversity. Increased application of industry has become a negative inevitable but so has the connectedness of humans to their environment. Modernism ideals have sacrificed ecosystem value for human comfort. Society has deemed human as most powerful, with the ability to alter the landscape whether for good or for bad. Forcing decline on the environment has become acceptable.

Biological remediation has the ability to restore cultural values through the reclamation of presently contaminated tribal lands. Recognizing that humans are only an aspect of the landscape plays a key role in reclaiming natural resources and ecosystems. Recognizing sensitivity of ecosystem services will create harmony between the environment and those connected to it.

Context

The night sky burns with light, but these are not the lights of hope. These are the lights of flaring oil wells, placed within tribal land. The largest shale oil field in the United States was discovered here, forcing industry into daily life. Fort Berthold Reservation lies on the edge of the Badlands in North Dakota. This land is home to more than 6,500 members of the Mandan, Hidatsa and Arikara tribes.

Crestwood Equity Partners discovered the spill five days after the burst, only after going through production loss reports. The wastewater flowed about 1.5 miles from the pipeline location failure. Fort Berthold plays a key role in the state's oil production, representing 300,000 barrels of North Dakota's 1 million barrels daily (Department of Mineral Resources).

Their land is now intoxicated with wells, fracking towers and waste, destroying the social fabric that has been imprinted within the reservation. Widespread poverty alongside human and environmental health issues have all been brought onto tribal land with the integration of industry. In July 2014, a million gallons of brine spilled from one of the many pipelines, releasing waste into a tributary of Lake Sakakawea, Bear Den Bay. These corridors provide drinking water to the reservation which are now contaminated by petroleum, heavy metals and salt. What is contained in these water bodies is deemed unsafe drinking water and subsequently killing wildlife and vegetation. Brine spills are releasing toxins into soils and waterways at levels exceeding quality standards, tainting land with radium and secreting high levels of ammonium in surface waters.

The plan for the site will provide environmental planning techniques to allow city and government exploration on the dire need of remediation for the well-being of culture and the ecosystem.

Typology

Environmental Remediation | Conservation Planning
The typology was chosen for the following reasons:

1. Encroachment of industry on Native American Reservations
2. Failing ecosystem services in Fort Berthold watersheds
3. Ability to create resilience for tribal communities
4. Restore environments and conserve sacred land

This project will stand as an example of an accepted and respected form of **remediation/conservation planning** on tribal land. It will implement the ideals of mutual respect between the biological and cultural values.

Specific consideration will be given to the values of Native American culture and their lifestyle as well as creating awareness on failing ecosystem services and declining environments. The finished design on the chosen site will establish the Lake Sakakawea watershed as a precedence for environmental remediation. Re-establishment of water quality and wildlife populations along the Little Muddy River will help to revive the current status of endangered ecosystems services and Three Affiliated Tribes population.

The finished design on the chosen site would establish Fort Berthold as a sustainable example for oil spill remediation and conservation planning on detrimental reservations.

“The land is a living body with spirit and power. It is necessary for the people to remain in the place in which they have always been, as guardians, and as an inseparable part of that place and space.”

-Stephanie Romero

typological **research:**

Things to Consider

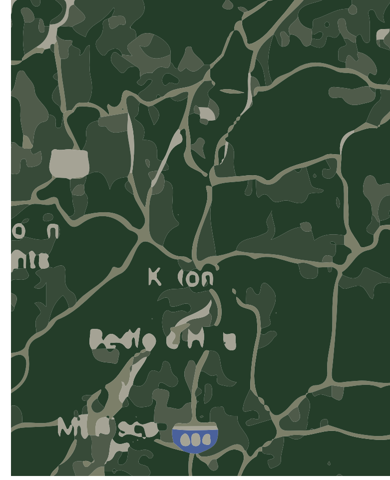
1. Sustainable strategies: water quality and management, topography, conservation, environmental ethics

2. Project typology: large scale - restoration & planning on site-specific and regional scales

3. Location: suburban & rural, sites requiring water management, soil remediation, community development and planning

4. Socio-economic context: areas overcome with industry and its effects, destruction & reconstruction of environmental and cultural integrity

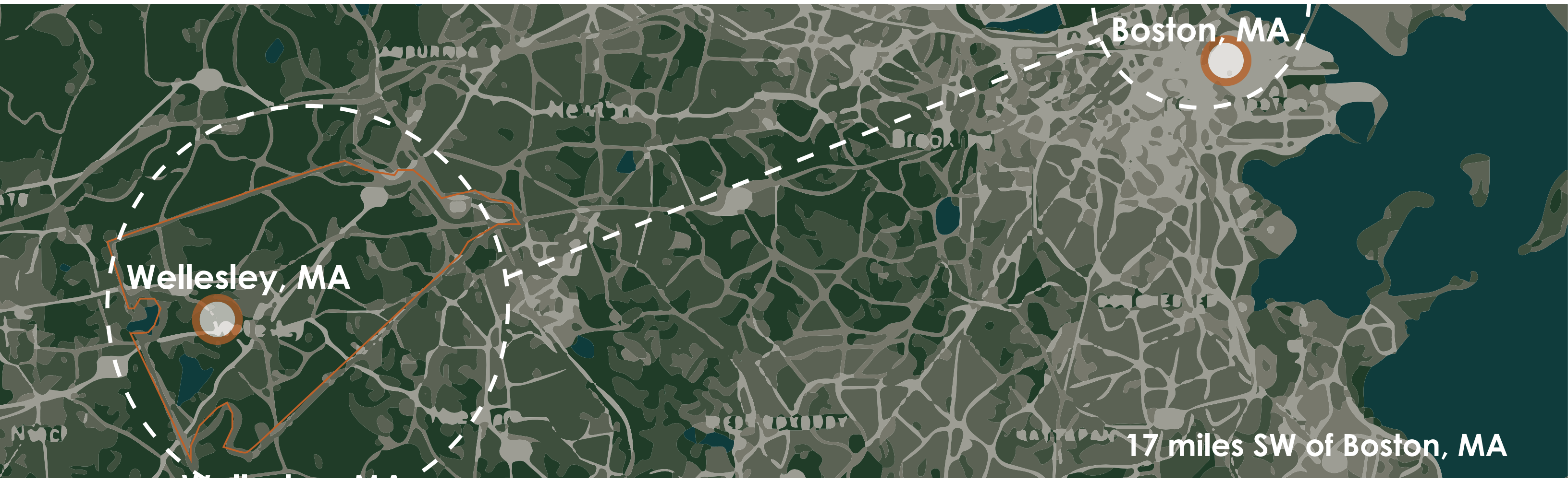
5. Design Impact: Leads to positive implementation and protection of environmental/cultural resources & sustainable efforts



Chosen projects:

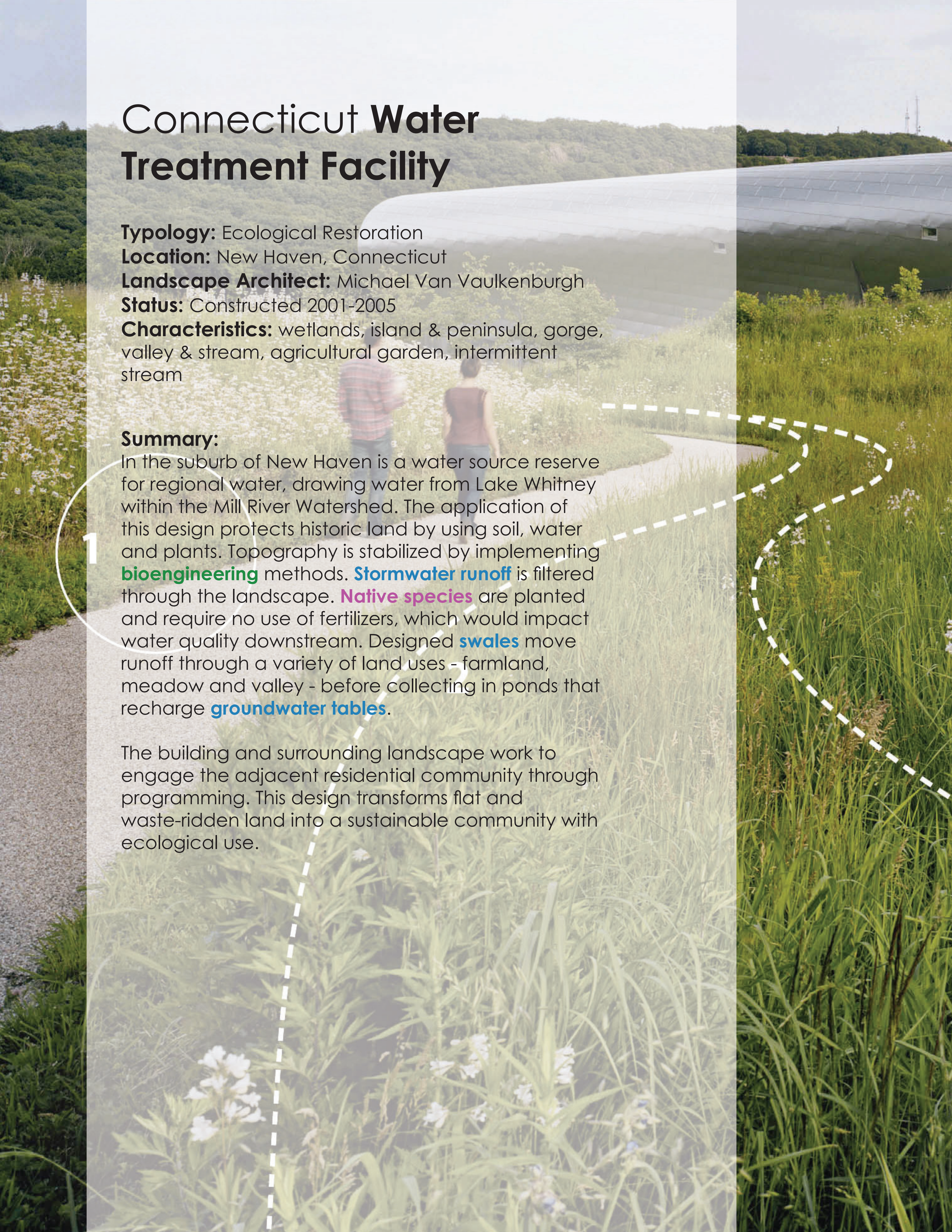
1. Connecticut Water Treatment Facility	New Haven, CT
2. Alumnae Valley Wellesley College	Wellesley, MA
3. I-25 Conservation Corridor Master Plan	Douglas County, CO
4. Resilient Nomadic Community	Hulunbuir, Mongolia


New Haven, CT
80 miles NE of Manhattan, NY


Boston, MA
Wellesley, MA
17 miles SW of Boston, MA


Denver, CO
Colorado Springs, CO
Douglas County, CO


Hulunbuir Region
Inner Mongolia
663 miles NNE of Beijing, China



Connecticut **Water Treatment Facility**

Typology: Ecological Restoration
Location: New Haven, Connecticut
Landscape Architect: Michael Van Vaulkenburgh
Status: Constructed 2001-2005
Characteristics: wetlands, island & peninsula, gorge, valley & stream, agricultural garden, intermittent stream

1

Summary:
In the suburb of New Haven is a water source reserve for regional water, drawing water from Lake Whitney within the Mill River Watershed. The application of this design protects historic land by using soil, water and plants. Topography is stabilized by implementing **bioengineering** methods. **Stormwater runoff** is filtered through the landscape. **Native species** are planted and require no use of fertilizers, which would impact water quality downstream. Designed **swales** move runoff through a variety of land uses - farmland, meadow and valley - before collecting in ponds that recharge **groundwater tables**.

The building and surrounding landscape work to engage the adjacent residential community through programming. This design transforms flat and waste-ridden land into a sustainable community with ecological use.


3
4

Connecticut **Water Treatment Facility**

Project Emphasis:
On a limited budget of $5 per square foot, this project fuses municipal infrastructure with community space and ecology. The landscape becomes a **'microcosm'** of the surrounding **regional watershed**, creating an engagement of the land and the flow of water. Reuse of on-site 40,000 cubic yards of soil allows topography to enhance and improve water quality and other hydrological processes. Techniques implemented in this design are drawn from restoration ecology and bioengineering and the protection of watersheds.

Surface runoff drains to an unlined pond where water is able to percolate through soil, which is later collected for storage. **Slope stabilization** and a meandering water edge allows for a variety of wildlife habitat.

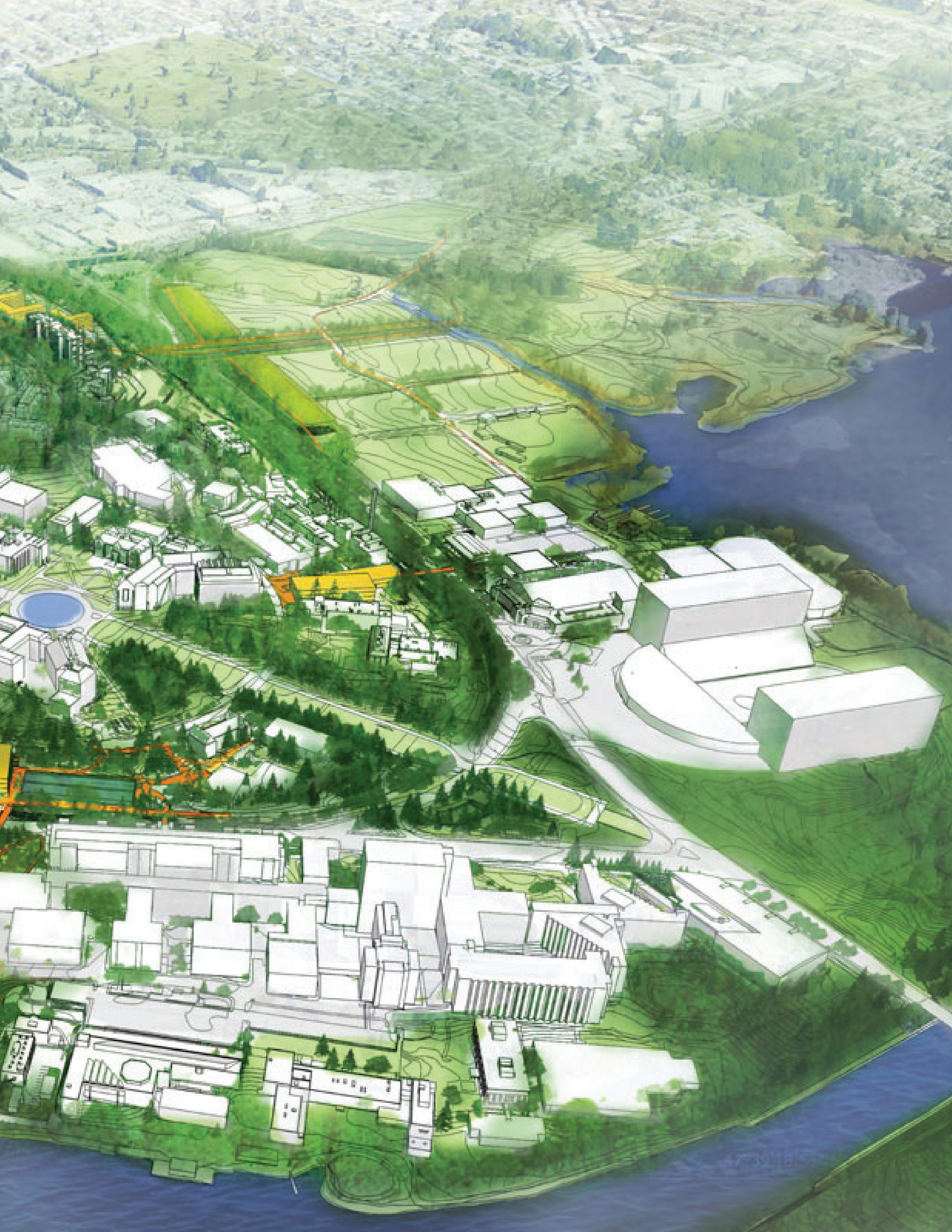
Important Takeaways:
Re-implementing and restoring the regional watershed through the use of **intermittent streams** shows the strive for sustainability. Water collection in ponds recharge groundwater tables as well as protects community and cultural values. Native species aid in **nutrient & toxin uptake**, minimizing the contaminants that are able to enter water and soil. Overall, the landscape provides essential ecosystem services that benefit the environment as well as humans that are designed to co-exist with them.

Alumnae Valley
Wellesley College

Typology: Brownfield Restoration
Location: Wellesley College, Wellesley, MA
Size: 13.5 acres
Landscape Architect: Michael Van Valkenburgh
Status: Constructed 2001-2005
Characteristics: meadow, wetlands, pedestrian thoroughfares

Summary:
Alumnae Valley, during the development of Wellesley College, became an industrialized natural gas pumping site. The site's soil remained toxic but was dealt with in removal and treatment. Heavily contaminated soil was **excavated** and removed for off-site treatment. By-products of natural gas were found in the ancient watershed beneath the parking lot. The site is capped with clean fill, while mildly-contaminated soil is used in **drumlins** for meadow plantings. Toxicity of the site inspired restorative solutions.

The destruction of natural hydrology and the 80-acre watershed of Lake Waban is now an **intermittent wetland** including a series of basins to treat site runoff water. The restored valley has been transformed back into hydrologic system that forms Wellesley College campus. Reconceptualization allowed the use of topography and plant selection allowed the landscape to become not only usable, but sustainable with ecosystem services.

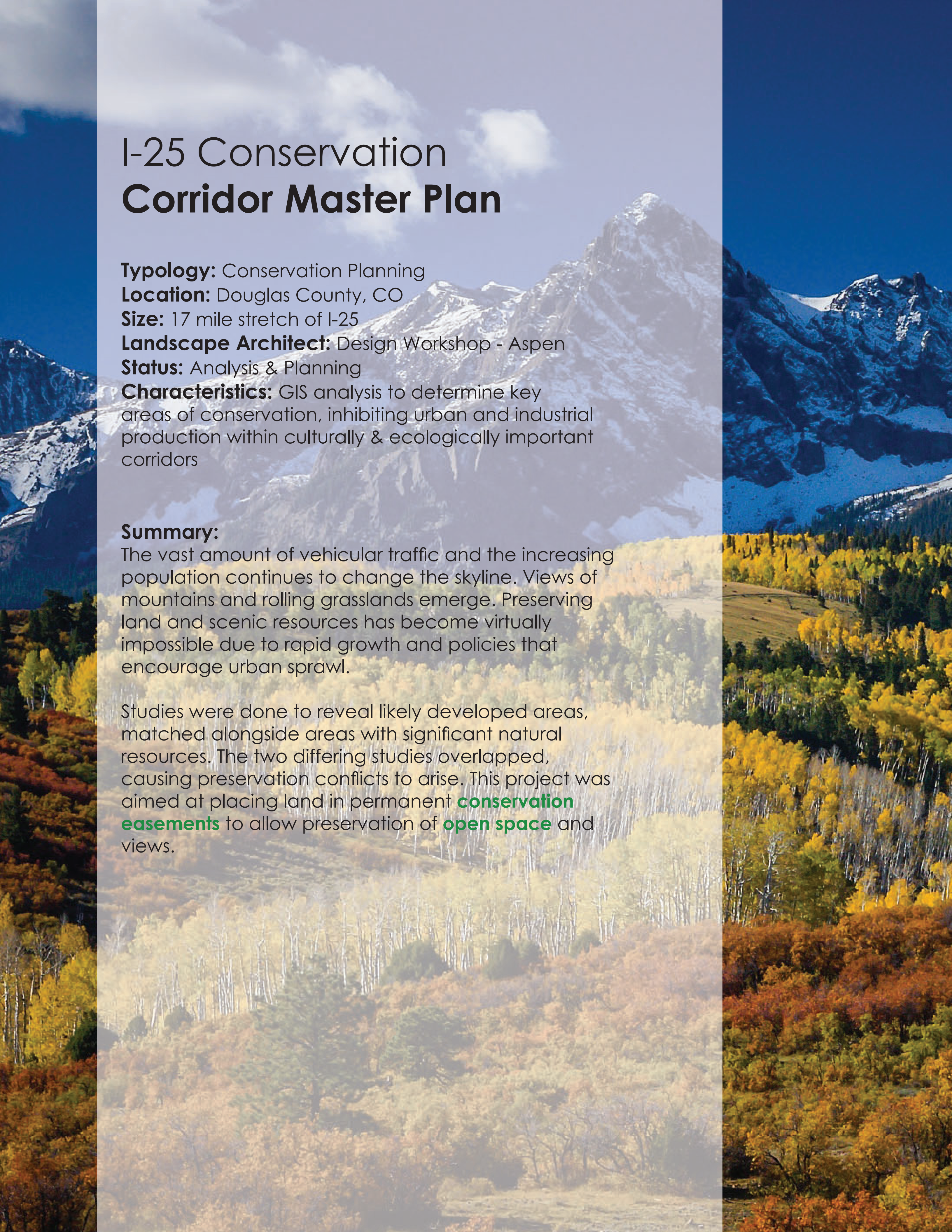


Alumnae Valley
Wellesley College

Project Emphasis:
Frederick Law Olmsted surveyed this site in 1902 and recommended the ecology and environmental communities to be preserved. However, industrialization brought on the toxicity of a **brownfield**. Topography plays a major role in the remediation of this site, allowing enhancement as well as laying the foundation for a new design to form. Alumnae Valley design does not follow the specifics of Olmsted's **preservation** recommendations but allows ecological services and systems to become a living part of Wellesley Campus. Meadow-planted drumlins hold mildly-contaminated soil, allowing for **phytoremediation** to take place on site. The cleansing of toxins before reaching the Lake Waban watershed is instrumental in preventing water from prematurely returning to the **water table**.

Important Takeaways:
Like the previous case study, this project focuses on sustainable stormwater management and creating space for social gathering. **Forebays** are implemented to collect sediment, **cattail marshes** provide uptake of toxic compounds, and an **infiltration basin** provides groundwater recharging opportunities. Alumnae Valley reconnects ecological systems and treats surface water through use of topography and hydrological design techniques. The design allows for contemplative gathering spots by being a visual and physical link between campus and Lake Waban.





I-25 Conservation **Corridor Master Plan**

Typology: Conservation Planning
Location: Douglas County, CO
Size: 17 mile stretch of I-25
Landscape Architect: Design Workshop - Aspen
Status: Analysis & Planning
Characteristics: GIS analysis to determine key areas of conservation, inhibiting urban and industrial production within culturally & ecologically important corridors

Summary:
The vast amount of vehicular traffic and the increasing population continues to change the skyline. Views of mountains and rolling grasslands emerge. Preserving land and scenic resources has become virtually impossible due to rapid growth and policies that encourage urban sprawl.

Studies were done to reveal likely developed areas, matched alongside areas with significant natural resources. The two differing studies overlapped, causing preservation conflicts to arise. This project was aimed at placing land in permanent **conservation easements** to allow preservation of **open space** and views.

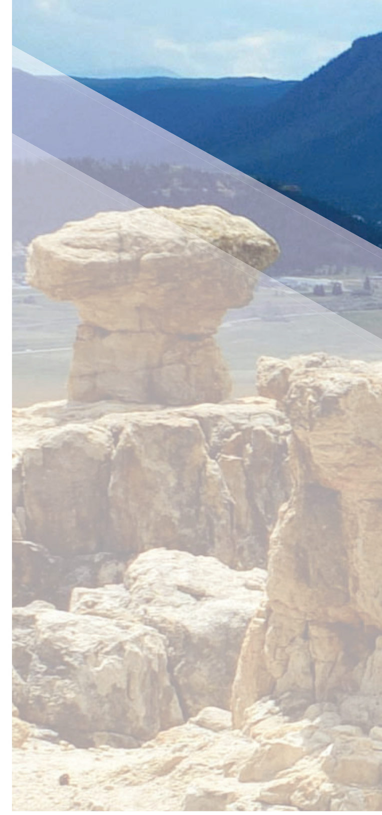
"If growth expectations in metropolitan Denver are strong, Douglas County's are at a gallop. With the coming explosion along Denver's southern I-25 Corridor and development in Colorado Springs, commercial and real estate developers are positioning themselves in Douglas County along the Corridor."

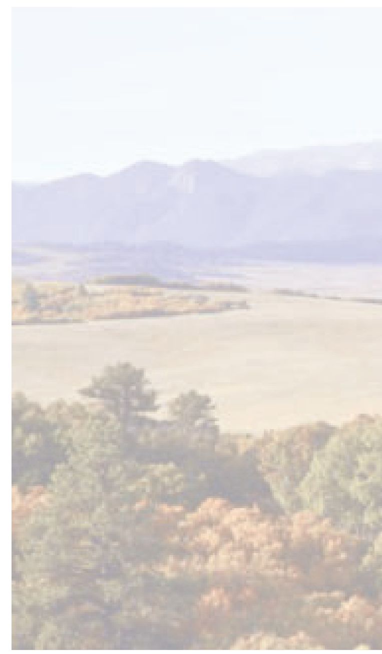
- Denver Business Magazine

I-25 Conservation **Corridor Master Plan**

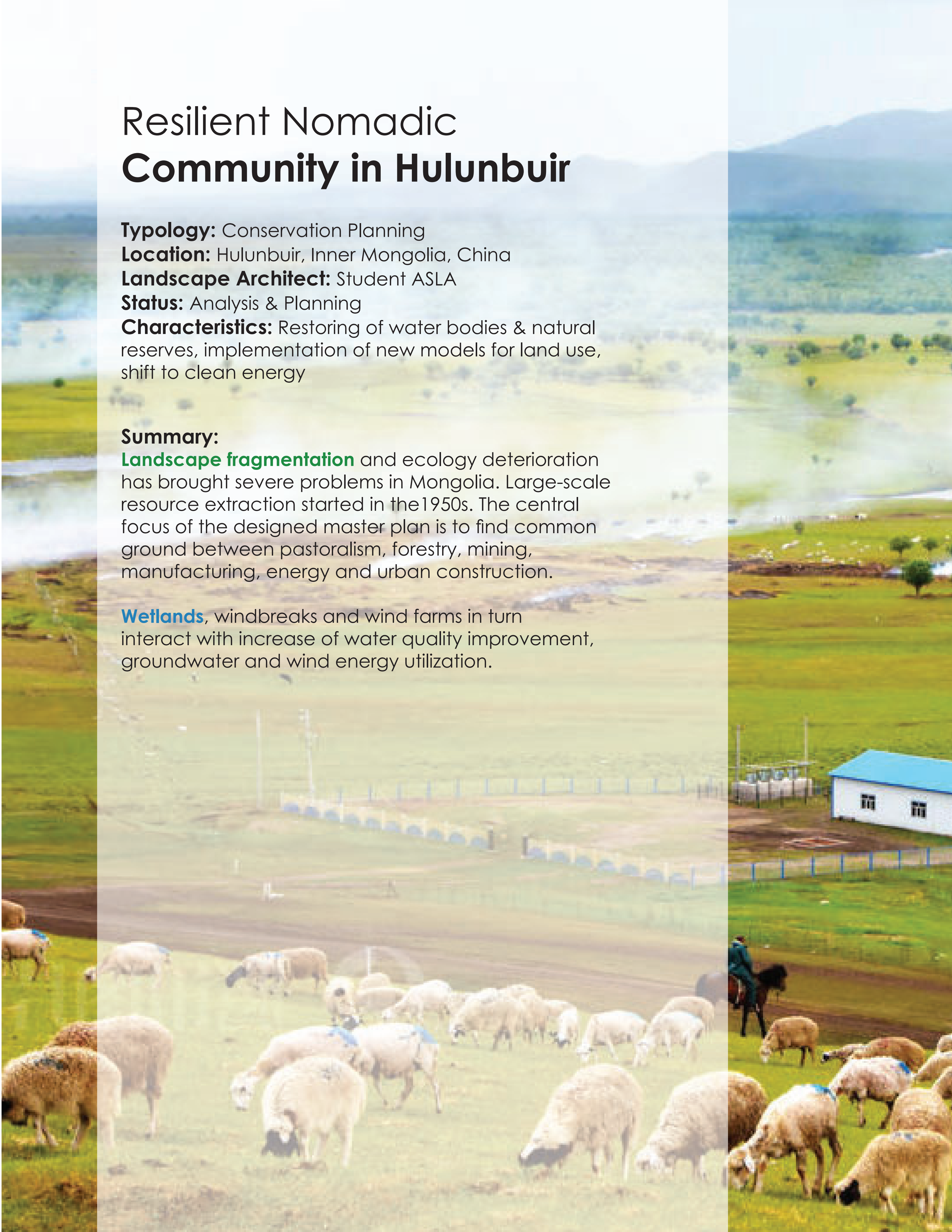
Project Emphasis:
The methods integrated inhibit poor development practices and in turn promotes smart development and preservation of natural resources and open space. Critical attributes of the landscape were analyzed; topography, land cover, hazards, zoning, wildlife habitat, groundwater and heritage sites. I-25 corridor is accessible to 3 million people who reside in the area. Areas with the best views and **cultural heritage features** were often the highest valued land, making conservation efforts essential. Using predictive modeling and suitability analysis, land was prioritized for conservation. To date, 32,000 acres of land appraised at over $100 million have been purchased and protected for less than 30% of market value.

Important Takeaways:
The most valuable takeaway from this conservation plan is the efforts made to **preserve** landscapes in present and future distress. It's vital that natural resources and ecological services remain detrimentally unaltered by human interaction. These landscapes hold societal significance, extracting data from citizen surveys. Residents firmly believed in open space preservation in areas of **wildlife habitat** and stream and river **corridors**. The importance is to place high priority on space that is integral in the continuation of culture. Predictive modeling will be helpful in my thesis in determine industrial impact and needs for remediation and conservation design.







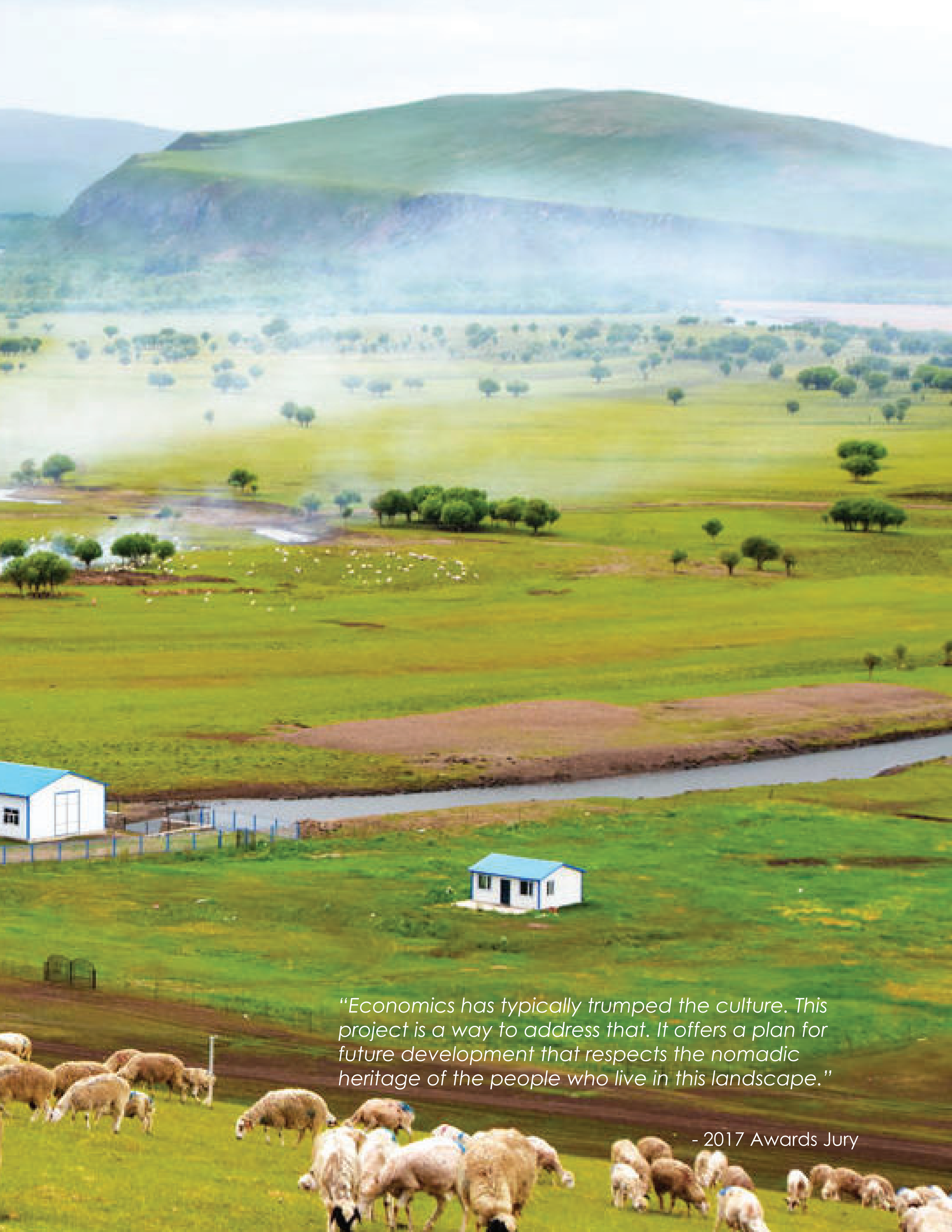


Resilient Nomadic **Community in Hulunbuir**

Typology: Conservation Planning
Location: Hulunbuir, Inner Mongolia, China
Landscape Architect: Student ASLA
Status: Analysis & Planning
Characteristics: Restoring of water bodies & natural reserves, implementation of new models for land use, shift to clean energy

Summary:
Landscape fragmentation and ecology deterioration has brought severe problems in Mongolia. Large-scale resource extraction started in the1950s. The central focus of the designed master plan is to find common ground between pastoralism, forestry, mining, manufacturing, energy and urban construction.

Wetlands, windbreaks and wind farms in turn interact with increase of water quality improvement, groundwater and wind energy utilization.



"Economics has typically trumped the culture. This project is a way to address that. It offers a plan for future development that respects the nomadic heritage of the people who live in this landscape."

- 2017 Awards Jury

Resilient Nomadic **Community in Hulunbuir**

Project Emphasis:
This project focuses on the rebuilding of **resiliency** within a nomadic community that had been overtaken and disrupted by industry. Analysis was completed based on a series of dynamic and complex factors that had been influencing the evolutionary process of the region. Inner Mongolia had lost large areas of grasslands due to political conflict and modernization, bringing traditional nomadic lifestyle to a near end. The proposal's cornerstone models how to operate in a changing environment from factors such as climate, shrinking of water resources and forests, the increase of industry and pollution and the decline of grasslands. In turn, strategies like restoration and conservation of water bodies were proposed, the shift to clean air and energy, and new land use models for minimally invasive tasks.

Important Takeaways:
As with the Colorado case study, both are determined to conserve and **reconcile** past land use for the benefits of not only the environment, but for the people as well. They looked at the land as an 'agent-based, **self-organizing system**, being resilient and adaptable to a changing environment throughout time'. The goal is to restore land to its natural state. As humans, we have become a detrimental part in environmental succession but there are ways to obtain quality through environmental remediation and conservation planning. Once we are aware that we are only a piece within the environment instead of the only piece, strives towards restoration can be made.



typological research **takeaways:**

The previous case studies were examples of how to protect land, resources and culture through conservation planning and environmental restoration. The willingness to preserve natural resources and its people are revealed greatly through typological research. Reaching the full potential of capacity of the site is solely dependent on the environment and people who interact with it.

Through research and analysis of each project specified in this document, certain key principles are found that link each site to one another. These commonalities will help to establish the vernacular and elements required to form a successful solution to the problem being posed currently on Fort Berthold Reservation.

Common Principles:

1. Water management and quality is key to sustainable communities
With Lake Sakakawea being a main source for drinking water, it is vital to rid sources of contaminants and propose ways of creating resilience against any future pollution. Water is not only an environmental value but a cultural value as well to the people on Fort Berthold Reservation. Designing for sustainability is fundamental.

2. Versatility and variety of restoration techniques
There is no end-all method to restrain contamination. Through various types of remediation research, it will be clear to see which would be most suitable in key areas of the site within Fort Berthold.

3. Land and its ecosystem services have the ability to impact surrounding culture

One thing that stood out to me while studying is the link between environment and people. Water is used for irrigation, drinking, cooking. Land is used for cultivation, building, Extraction of resources such as oil, coal, natural gas is inevitable but there are sustainable ways to mitigate human force on the environment. When these resources are gone or are being handled inadequately, the way of life for those affected are changed drastically. A robust environment goes hand-in-hand with a robust culture.

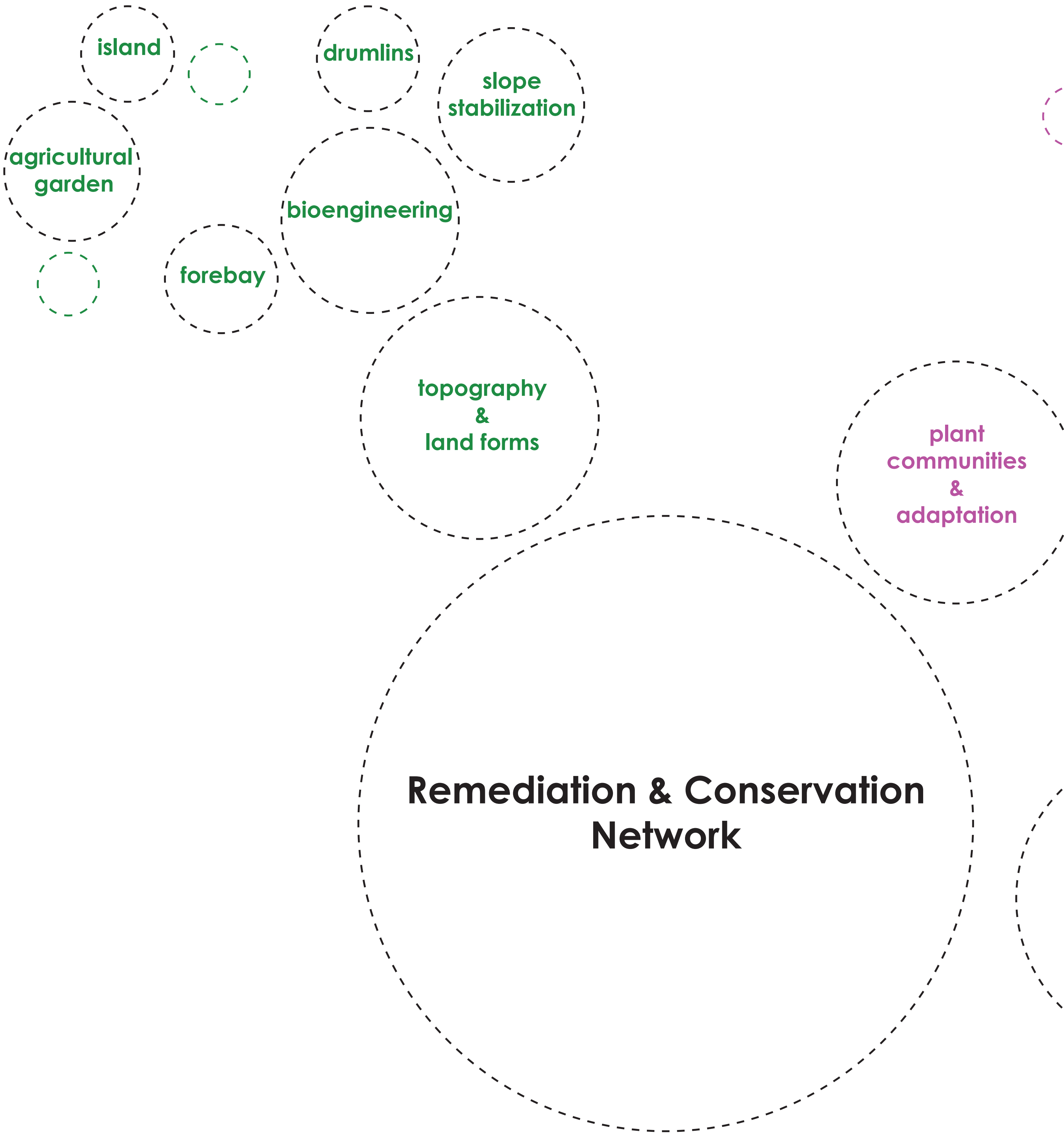
4. Balance co-existence of natural and human resources

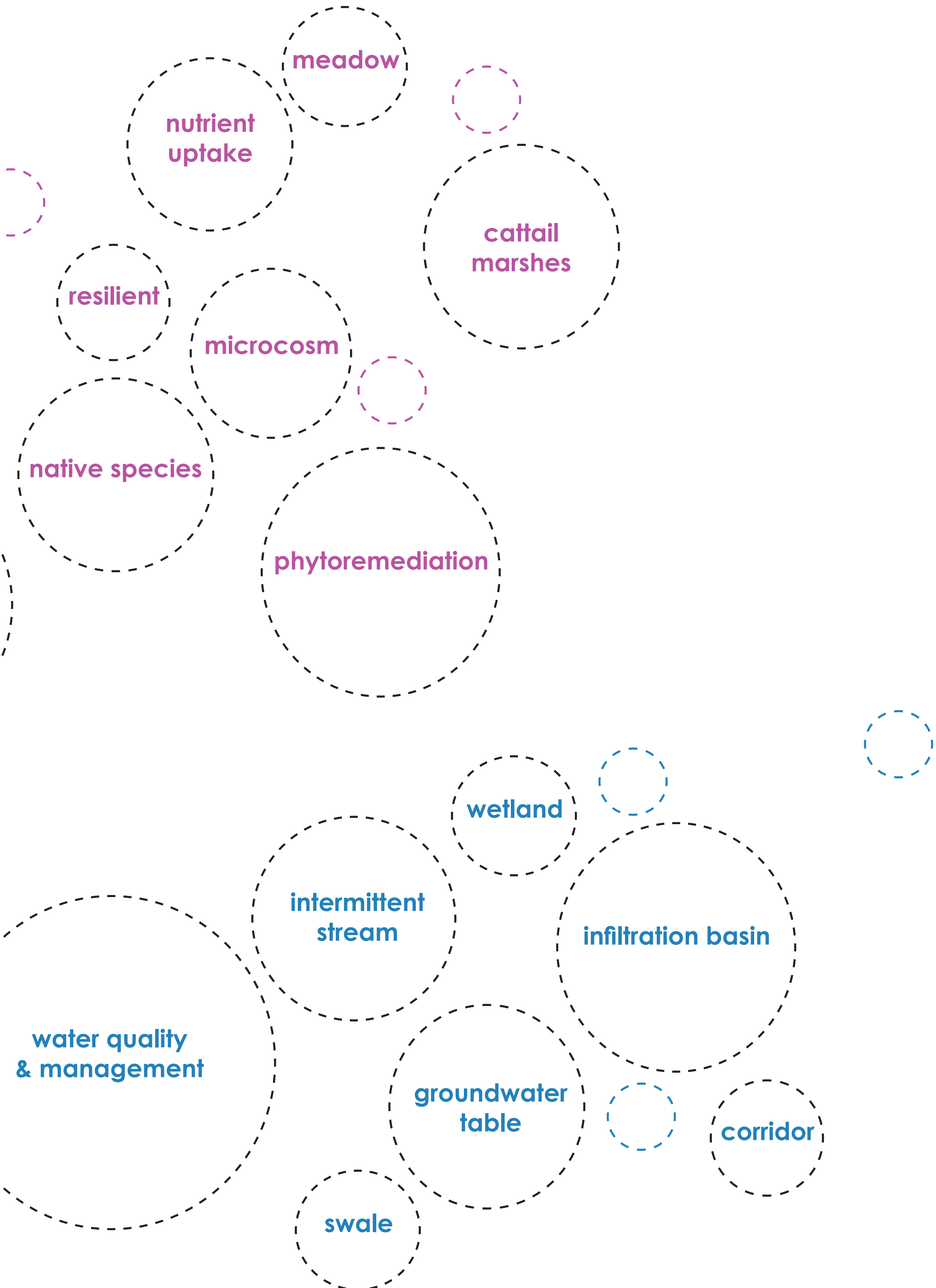
Humans rely on ecosystem services for living, working and playing. However, human ideals often trump environmental sustainability. This design will focus on the meshing together of the two factors in order to establish a community which can thrive off one another instead of causing repercussions.

5. Remediation + Conservation = Resiliency

The overarching idea. How can a design promote and restore environmental stability and encourage cultural growth? How can a design protect against the certainties of the post-industrialization era without forcing change on people who are wanting to retain their history and beliefs?

bodies of **knowledge:**




meadow
nutrient uptake
cattail marshes
resilient
microcosm
native species
phytoremediation
wetland
intermittent stream
infiltration basin
water quality & management
groundwater table
corridor
swale

"We are the soil and the soil is of us. We love the birds and beasts that grew with us on this soil. They drank the same water as we did and breathed the same air. We are all one in nature. Believing so, there was in our hearts a great peace and a welling kindness for all living, growing things."

-Luther Standing Bear

major project **elements:**

Watershed & Stream Modeling
Analyzing Fort Berthold's watersheds will show water movement across the regional scale. This will reveal water movement patterns from surface runoff as well as where potential contaminants will collect and move downstream. Clustering this data will help to find sites suitable for remediation and future resilience planning.

Oil Pads & Pipeline Location Analysis
GIS Mapping of these features will reveal how these sites interact with water movement. Pipeline bursts and oil pad point data will show where contaminants and oil will spread and runoff based on exact locations of spills.

Land Cover Use Distributions
Analyzing various land covers and uses such as grasslands, urban development, forest, farmland, etc., combined with the two elements above can disclose land types that are endangered with the need of being protected and conserved for the benefits of ecosystem production and cultural values.

Fort Berthold Communities & Values
It is vital to understand cultural values of the Three Affiliated Tribes to understand what is essential for inclusion within the design process. Reclaiming priceless ecosystems and elements allows re-creation of communal values and sense of place to occur.

Phytotechnology & Contaminant-Specifics
A major project element for this thesis is to utilize remediation techniques for toxins and compounds such as petroleum, salts and heavy metals will provide information on how to sustain troubled environments on Fort Berthold Reservation.

Conservation Planning Methods
This thesis design focuses on the restoration of contaminated tribal land and the need for preservation. Protection of water, land, soil and community are crucial for the advancement of environment and human aspects.

the **user:**

The user for this thesis will primarily be the Three Affiliated Tribe residents and enrolled members within the Fort Berthold Reservation who have been struggling with the decline of their environment and culture since the oil boom in the Bakken began in 2006. With the implementation of pipelines and oil pads within their community, their livelihood and way of life has taken on downward-spiral.

- Fort Berthold Reservation Population : 6,341 (2010 Census)
- Fort Berthold Tribal Enrollment : 15,013 registered members (2016)

Physical Restrictions:
Depending on where my site is, the development and conservation efforts will occur on either tribal land or federal government land within the reservation. Federal land conservation programs would provide funding to maintain and preserve new land and community functions.

Peak Usage:
This aspect will depend on my analysis to determine which typology would be most suitable for my site. Environmental remediation in the form of an ecological park would be utilized year-round by the environment, filtering out elements that are unwanted from industry. Human usage would be most utilized throughout spring, summer and fall where users could go the site and experience and learn about how certain plants and buffers alleviate contamination to soil and water.

Conservation Planning:
Through the implementation of resilient communities on the reservation will be used by its residents year round, serving as a place to live, work and play without the repercussions of outlying business.

Economic Issues:
This has been a long-standing issue for those on Fort Berthold Reservation. Land and sacred resources have been stripped, at the cost of their financial livelihood. There are many hardships to overcome in order to sustain business and income, making Native American communities prone to poverty.

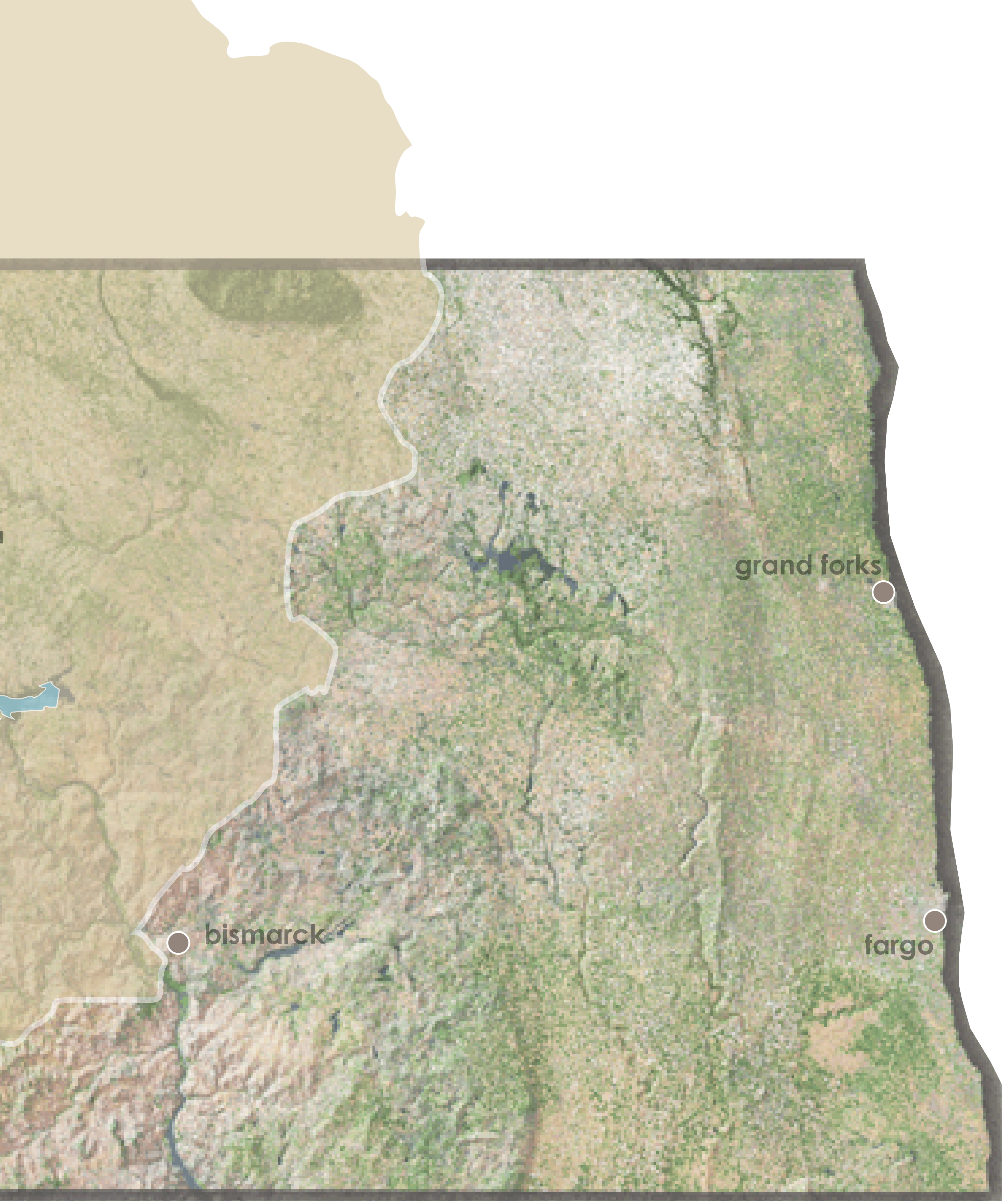
thesis **site:**

Location:
Fort Berthold Reservation

Land Size:
988,000 acres
457,837 acres tribal owned

Lake Sakakawea:
168,320 acres

Communities:
Mandaree
New Town
Parshall
Twin Buttes
White Shield
Sanish



macro | state of north dakota

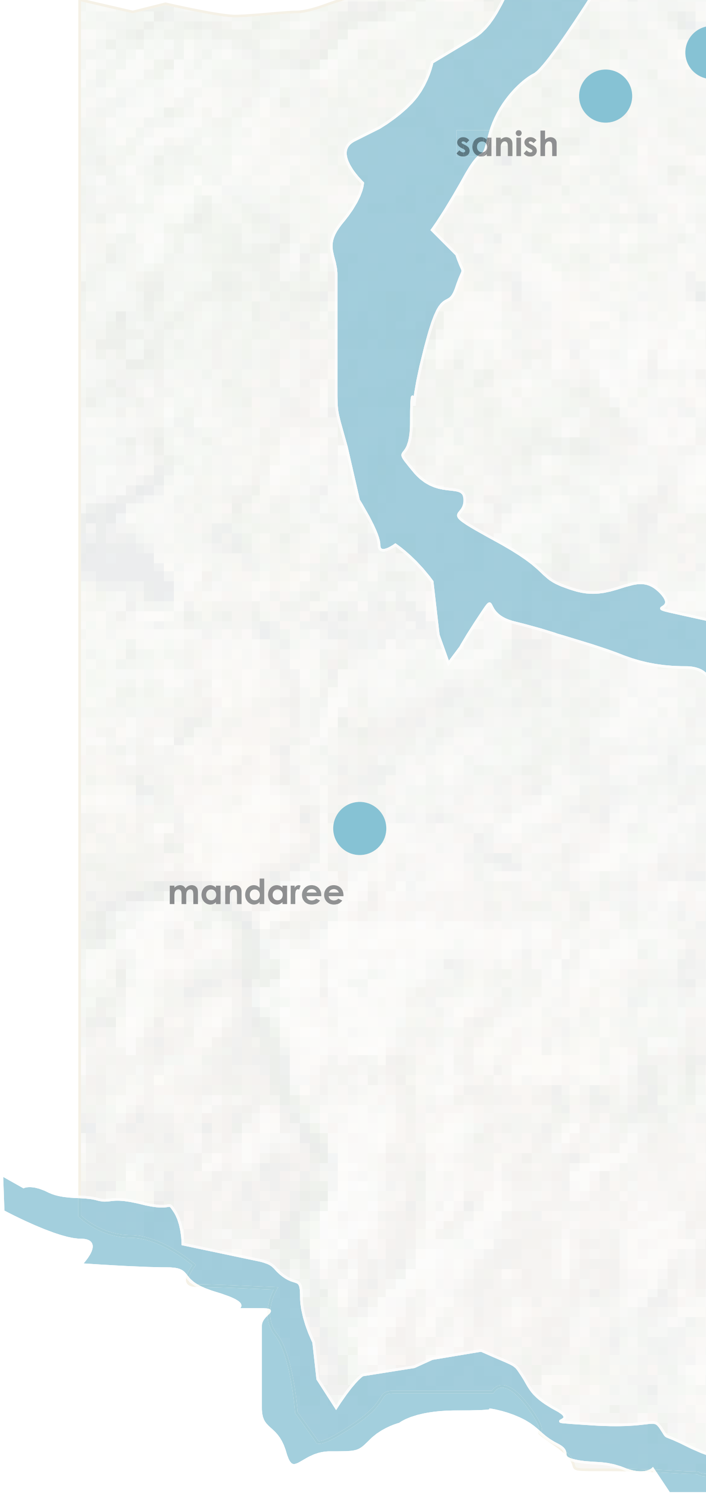
Site Selection

The loss and destruction of tribal land reveals the distressed relationship between the federal government and Native American tribes. As tribes lose land rights and the ability to sustain an economy are forcing Native Americans to suffer, in financial and health. The discharge of the oil and natural gas industries have caused ache within Fort Berthold tribal communities.

1. Location
The location is extremely important because this is one reservation that has been struggling culturally and environmentally with the hazards brought upon them by the oil industry. There is an inherit sense of place felt by the Three Affiliated Tribes and their land and community values need to be restored.

2. Potential
The site is nearly a blank slate. Although there is industry and some urban development, there is open land that has been contaminated through industry integration. Sacred resources are needed to be remediated in order for the land and its people to continue to thrive.

3. Overall Mission
The overshadowing idea is to create plan that can help reintegrate Native American values of culture and environment back onto the land and preserve these resources for future generations.



meso | fort berthold reservation

project **emphasis:**

1. Defining environmental and social sustainability on reservations
This is an important step to establishing overall goals for the thesis project. Not only am I striving to restore existing environmental issues on site, but I am also looking to revive destroyed culture from implementation of industry. With a better understanding of what these specifically look like within troubled communities.

2. Implementation of phytotechnology and restoration
With the increase of contaminants on site with the spills of oil pads and pipelines, various types of phytoremediation and soil stabilization will be needed. Although brine spills are extremely difficult to clean up, I hope to find viable solutions that can be used in the future to reduce environmental and cultural impacts to sites that fall victim to spills.

3. Utilization of analysis technology
Application of GIS withholds substantial data; land cover and use, soil analysis, watershed and stream movement with the incorporation of existing pipelines and oil pads within the site region will allow me to determine specific affected areas that need restoration and protection. GIS will be instrumental in selecting suitable sites and design types and performance.

4. Creating resilience for culture and natural resources
As land changes the resources on them change as well, for good or for worse. When those resources are expended, we are left with only memories of what was, instead of preserving and prolonging. Throughout my design process, I hope to emphasize the need for conservation for both environmental and human communities.

5. Precedence for Landscape Architecture of the future
I believe my project will be a viable solution to problems that our communities face every day in the face of modernization and industry. How will this progress in the coming years? The realization of loss is among us. Thinking more in depth about the answers will help to solidify the importance of ecosystem services and the implementation of conservation methods.

thesis **goals:**

1 **Explore design strategies within the realms of environmental remediation and conservation planning**
Understand how the two typologies can co-exist and create an vital social and ecosystem interaction that will allow both sectors to thrive.

2 **Successfully communicate the importance ecosystem and cultural restoration**
Once it's gone, it's gone. There is no turning back, only what-ifs. Analyzing and designing for protection and resilience is crucial for the existence of natural and human resources.

3 **Learn more about the power of GIS**
Gain knowledge that will help me academically and professionally for future work. GIS is an essential tool in site analysis. Expanding what I know about the software will definitely prove beneficial in firm settings.

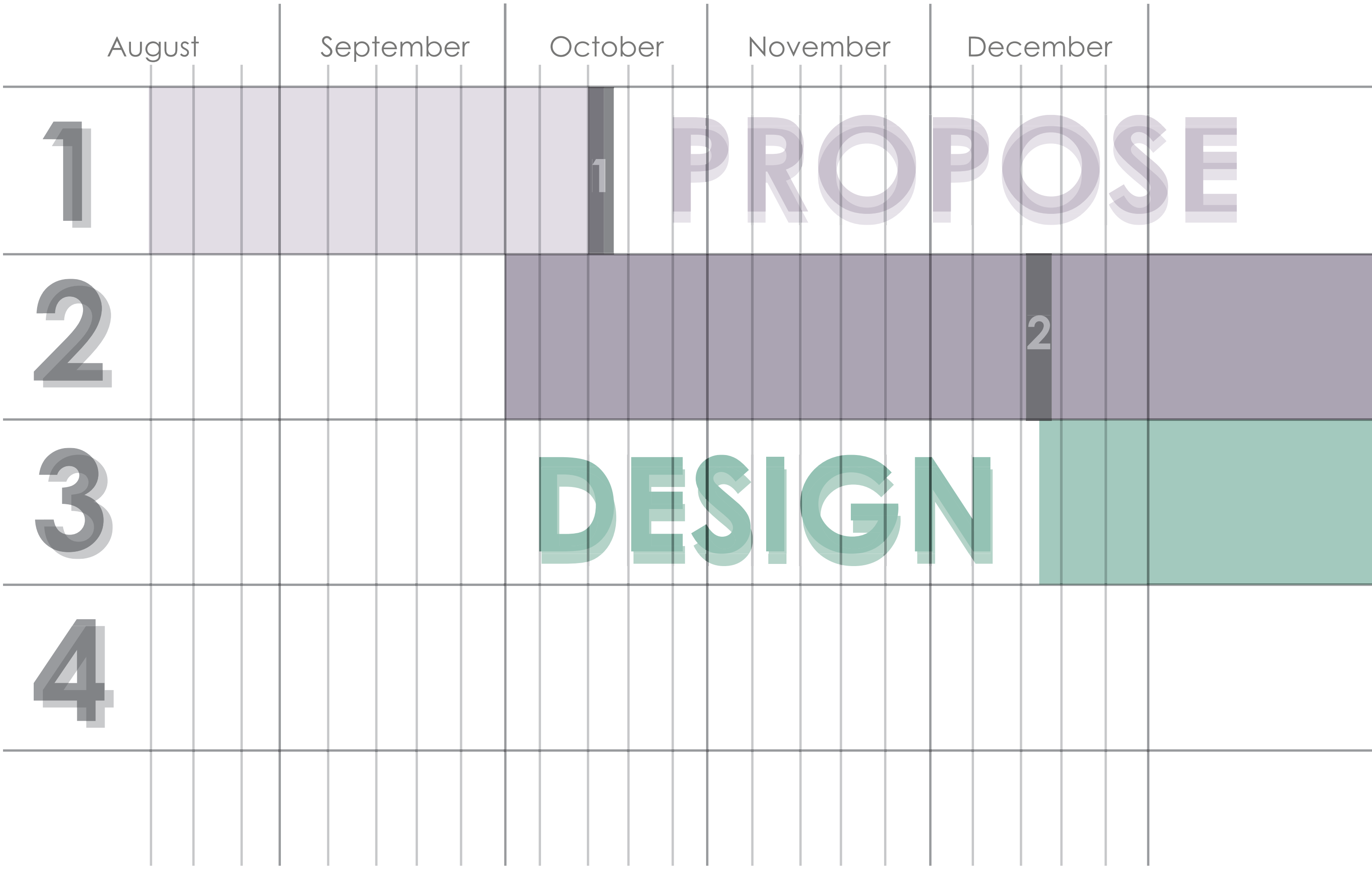
4 **Increase my design abilities through study and execution**
Continuing to practice my obtained design skills but be willing to step out of the box and try new techniques that may enhance the overall visual presentation.

5 **Obtain my Masters of Landscape Architecture degree:**
This has always been the goal. Stay focused. Stay excited. Stay driven. Continue to meet and surpass expectations throughout the entirety of the thesis project.

6 **Create a thesis project that fully reflects my design intention and research:**
I hope to effectively bring my ideas and research together through one cohesive design that reflects a long road of research and design process. Successfully finalize a long-road of work through showcasing a viable solution to an ever-growing environmental and social problem.

7 **Stress but don't stress too much**
Some stress is good, but I hope to keep mental breakdowns to a minimum. Of course there will be times when it seems like the process will never end, but to always keep in mind that the final goal will be worth the late nights at studio.

project **schedule:**



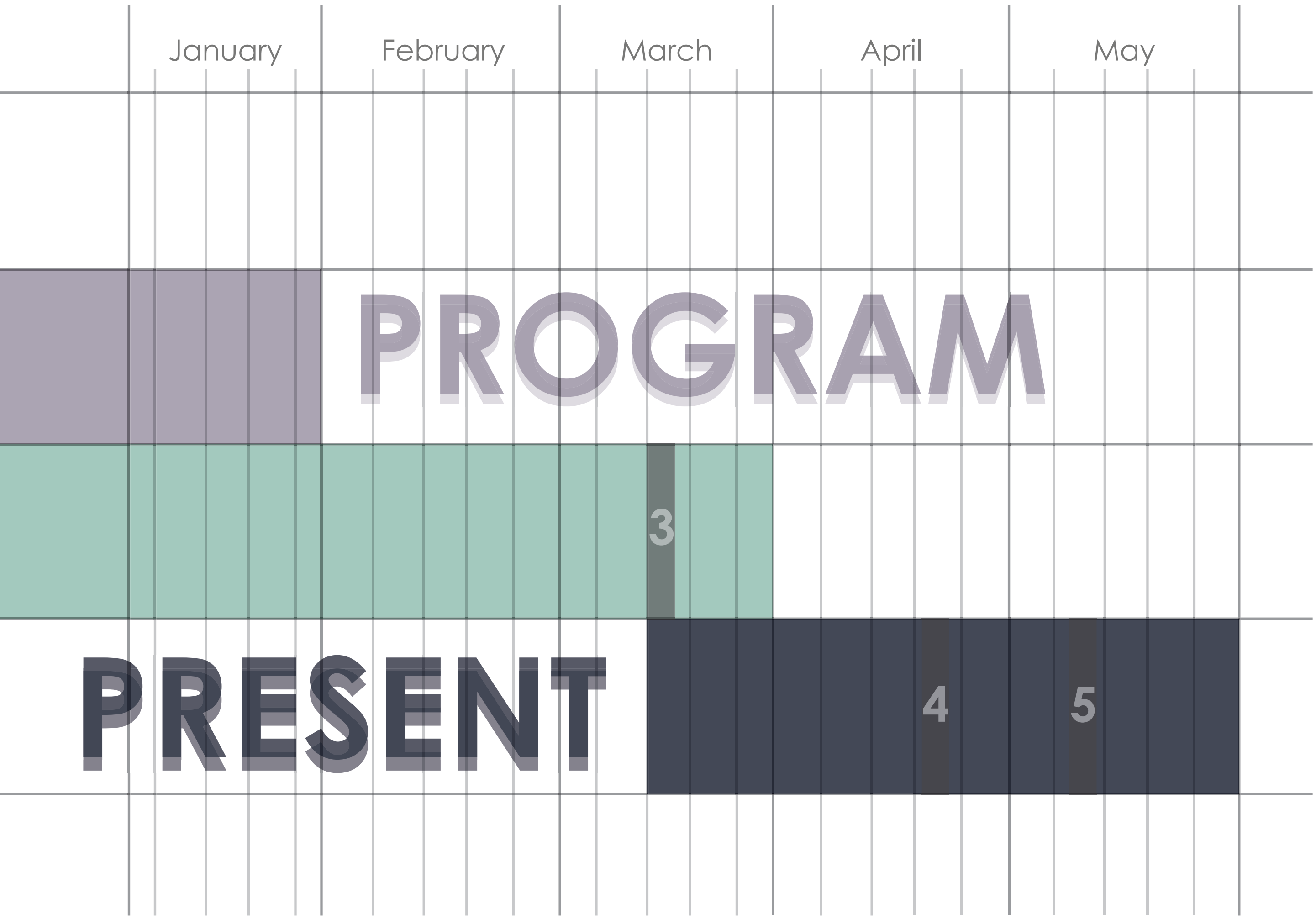
1. Proposal
This phase began back in May when we began brainstorming thesis topics and landscape architecture interests; it will conclude with this document submission.

2. Programming
Programming began after the final typology and site were decided. This occurred for me at the end of September. The finalized program will be submitted March 8th, 2019 as the presentation phase begins.

Key Dates:

1 Thesis Proposal Due 10/11

2 Thesis Program Due 12/12



3. Design

The design phase will begin near the end of November after data collection and analysis have progressed and will end when ‘production month’ begins. This phase contains the bulk of the work (see following page for details).

4. Presentation

This is the final phase which involves communicating with the developed solution. This will begin in early spring and conclude with final project submissions.

Key Dates:

3 Final Program Due 3/8

4 Digital Exhibit Due 4/19

5 Thesis Book Due 5/10

Thesis Dates & Deadlines

Fall Semester 2018

21 August	First Full Day of Classes
21 August	First Meeting of LA 763 Course
13 September	First Draft of Thesis Proposal Due
27 September	Draft of Thesis Narrative Returned
11 October	Thesis Proposal Due
25 October	Thesis Program Draft Due
22-23 November	Thanksgiving Holiday
7 December	Last Day of Classes
12 December	Final Thesis Program Due

Spring Semester 2019

08 January	First Full Day of Classes
04-08 March	Mid-semester Thesis Reviews
11-15 March	Spring Break
19-22 April	Holiday Recess
19 April	Thesis Project Final Digital Exhibits Due
22 April	Physical Exhibits Due
23-26 April	Annual Thesis Exhibit Opens
29 April - 02 May	Final Thesis Reviews
06 May	Digital Copy of Thesis Documentation
06-10 May	Thesis Awards Finalist Show
10 May	Final Thesis Document Due in IR
11 May	Commencement at Fargodome

presentation **intention:**

The final documentation and presentation of this thesis study will utilize a variety of mediums to convey and summarize aspects of the design process. There will be a mix of required and non-required material including:

- The Project Book: In addition to or in conjunction with the thesis proposal document, the project book will include a full report of the design process, solution and final takeaways. The book will be turned in prior to its due date on May 8th, 2019.

- Project Boards: A printed graphic will accurately display the design thesis as well as the design solution. Boards will be used in conjunction with the Presentation (see below), and completed prior to the digital-copy due date of April 19th, 2019.

- Physical Model: A physical, scaled model depicting the existing as well as the designed solution and surrounding site. The model will be constructed with a high level of accuracy to fully represent the environment suggested by the final design. Model to be completed prior to the opening of thesis exhibit on April 24th, 2019.

- Thesis Presentation: An oral and digital presentation put together per the requirements and presented at the end of spring semester. Project boards and model(s) will be showcased during the presentation and will mark the conclusion of the Master of Landscape Architecture Program. Presentation is to be given during designated timeslot between April 29th, 2019.

A digital copy of the complete project will be published to the North Dakota State University Institutional Repository and will be available for viewing across the globe.

plan for **proceeding:**

Definition of Research Direction

A project goal of mine that will be crucial to thesis success is to sticking to the schedule. I hope to maintain my planned and manageable pace to ensure that all phases of research and design are thorough and complete to exceed project standards. The first step of this schedule was the completion of the thesis proposal document.

Moving forward, per the project schedule, work continues to research and develop a comprehensive program to meet the requirements of this semester's Thesis Preparation Seminar. After a critique of the proposal and program, all necessary modifications will be completed before moving in to the third phase that is design.

In the design phase, I will apply tools and methods that I had developed and analyzed in the prior phases of proposing and programming. The design phase will be the most extensive of the 4 phases and can be broken into sub-phases as follows:

1. Preliminary planning and analysis
2. Project solution development and approval
3. Technical details and modeling
4. Solution administration and presentation execution

These phases of design are planned to mirror the typical phases of the professional landscape architectural process; **research, conceptual and schematic design, design development, construction documentation and construction administration.**

Design Methodology

Mixed Method | Qualitative & Quantitative Approach
Both qualitative and quantitative data will be gathered concurrently, with integration of said data occurring at several stages within the research and design process depending on the requirements of the unifying idea. The analyzing and interpreting of my findings will also occur throughout the researching portion and will be presented in text and graphic forms.

- **Quantitative Data** | Statistical | gathered & analyzed through obtained archival searches
- **Quantitative Data** | direct observation | survey | community involvement

Documentation of Design Process

Question:
Identify the site problem and constraints. Start analysis of region, county, site to over magnify data from GIS and previous environmental remediation and conservation planning research until design visions surface.

Conceptualize:
Based on research, determine solutions and continue to brainstorm other new ideas that will best fit the site and its ideals. The creation of schematic diagrams and sketches will be vital to visual placement, use and importance based on site parameters and problems.

Plan:
With more detailed diagrams and plans, list solutions and materials that are needed to solve issues. Determine interaction of parts until a positive solution is formed. Identify where key locations are in relation to the designed moving parts to determine success and connection of problem to purpose.

Design:
Stick to the schedule. Test issues. Move from 2D to 3D modeling and through to the final stages of rendering to get a visual of real-life implementation.

Improve:
Design is never finished. There is always room for improvement and new ideas. What works well or what could function better? The final stage is recognizing these issues and solving them as effectively as possible before project realization.

The final design solution will be completed by April 19th, 2019 to allow for plenty of peer review and advisor critiques. Changes will be updated and there will be substantial time to put together the presentation materials. All of this will conclude with the final thesis presentation described in detail in the Presentation Intention section.

A list of the analyzing and design software to be used can be found in the important resources section of the appendix.

design **program**

literature **review**

Abstract

Over half of the 135,000 miles of oil and gasoline pipelines in the U.S. were installed before 1969, with implementation of pipes occurring before maturation of steel or coating technology. Leaks and spills are becoming increasingly common within the realm of man-made environmental hazards. North Dakota is the second largest in oil production in US, suffering from 85 paramount oil spills in last 20 years. North Dakota tribal lands are faced with declining environmental issues as a majority of reservations located in areas of hazard, creating a state of crisis within their livable environment. A broken pipeline burst more than a million gallons of saltwater into Charbonneau Creek, a tributary of the Yellowstone River in Northwestern North Dakota, causing massive die-off of fish, plants and the tainting of productive soil and drinkable water sources. Most spill damage directly effects Native Americans, who are most reliant on environmental health and stability.

Oil spills are extremely unpredictable, with little available information of when, where and how they occur. Beyond this, there are few remediation or planning strategies to be executed when these spills transpire. While most literature focuses on the reporting policies and response actions of spills, this study will propose an analytical strategy to mitigate the environmental threat of oil spills to water resources through environmental planning. Geospatial and hydraulic modeling tools will be introduced using National Hydrography Dataset for watershed-based drainage delineations, basin characteristic visualization, and streamflow estimation. A variety of remediation and planning studies will be examined and analyzed to inform environmental intervention. The result will present a landscape conservation and resiliency plan to include hazard identification, vulnerability analysis and ecological planning for an endangered watershed area on Fort Berthold Reservation near Mandaree, ND. The goal is to provide new perspectives on possibilities of creating a more resilient and sustainable tribal community.

Environmental Hazards within the Oil Industry

Brine wastewater spills are releasing toxins into soils and waterways at alarming rates, exceeding the nation's water quality standards. One gallon of wastewater or oil can make nearly a million gallons of freshwater undrinkable. This improper disposal of these contaminants percolate and infect the ground water, damages the surface soil, water resources and inhabitants of the affected area. With increased implementation of wells and pipelines, the number of spills and leaks have followed. In the United States on average, from 1986-2013, one significant oil or gas pipeline incident occurred every thirty hours. Spills and pipeline failures transpire in a variety of ways such as mechanical failure, human error and/or subfreezing temperatures which cause ruptures within the system. The implementation of metals into water sources inhibits carbon, sulfur and phosphorus mineralization and nitrogen transformations, hindering photosynthesis and reproduction cycles. Due to the rise in spills, corruption of natural resources has multiplied. Only about 20% of oil compounds degrade within water, revealing 35x the level of ammonium and selenium in sampled water that United States Environmental Protection Agency considers safe for freshwater aquatic life and use.

Issues of Oil Industrialization in North Dakota

North Dakota is ranked number two in the nation is oil production, just behind the state of Texas. Approximately 8,000 miles of regulated hazardous liquid and pipelines run across the state, with loose regulations on oil spill reporting. Prior to 2017, North Dakota had one of the strictest requirements for oil and saltwater spill reports. Any spill greater than one barrel, 42 gallons, was to be disclosed to authorities. However, the state does not require that the public be notified in the event of an oil spill, making it a closed-door industry. A new rule passed through legislation in August of 2017, allowing "contained" spills under 10 barrels to be swept under the rug. An analysis of spill data from 2008-2015 revealed that more than 8,000 spills were recorded with over 14 million gallons of brine documented. Research in many regions throughout the nation have shown that contamination from fracking has been fairly sporadic and inconsistent. In North Dakota it is widespread and persistent, with evidence of direct water contamination from fracking. A more condensed and recent analysis from 2013-2017 found that 42% of oil and 57% of brine spilled was uncontained, spewing nearly 37,000 barrels of oil and over 165,000 barrels of toxic saltwater. Lack of regulation and expansion of industry has enabled an average of 4.4 spills a day across the state since 2013.

Oil Spill Incidents in North Dakota

A number of large spills have dispersed since the Bakken started to flourish with industry in 2006. During this same year, more than one million gallons burst into Charbonneau Creek, a tributary of the Yellowstone River near Alexander, ND from a three-inch underground plastic pipe. Contamination of the creek, aquifers and surrounding ponds caused massive die-off of fish, turtles and vegetation. Eight years later, the creek has been repopulated with fish and vegetation, but the ponds and underground aquifer remain tainted despite restoration efforts. In 2012, 153 pipeline bursts led to 495 barrels of crude oil and brine were spilled. In July 2013, a lightning strike was said to have caused corrosion within the pipe. This ruptured a 35-mile long section of underground steel pipe that runs from Tioga, North Dakota to the Canadian border. Tesoro was unaware of the spill, leaving it unreported for two weeks. By the time the incident was observed, 840,000 gallons leaked in nearby agricultural fields. The largest spill in North Dakota history occurred in January of 2015 at Blacktail Creek, north of Williston.

Over three million gallons of saltwater leaked from Summit Midstream pipeline, elevating levels of chloride and bromide anywhere from five to ten times the upstream concentrations. During this period, radium activities were fifteen times the upstream, revealing a 2.5% downstream survival rate of fish bioassays compared to 89% upstream. Blacktail Creek is a third-order tributary of the Little Muddy River which flows into the Missouri River at Lake Sakakawea. Land cover in the region of the spill is 72% agricultural, 4% residential and 24% scrub and wetland. Although humans may not have been impacted directly, the toxicity of the soil, water and wildlife have made remediation a difficult and expensive process.

The most recent large oil spill occurred in December 2016 in Belfield, North Dakota under the ownership of Belle Fourche Pipeline Company. Nearly 130,000 gallons spilled into a tributary of the Little Missouri River with another 46,200 gallons leaking into a hillside. The rupture impacted thirteen acres of land and contaminated 5.4 miles of Ash Coulee Creek. Crude oil migrated almost six miles from the spill site along the creek. The six-inch steel Belle Fourche pipeline is mostly underground but was built above ground where it crosses Ash Coulée. This contamination fouled an unknown amount of private and U.S. Forest Service land along the waterway. With the increased amount of pipeline construction, leaks and spills are becoming more prominent throughout the state, with regulations becoming thinner and less refined.

Fort Berthold Reservation

The Mandan, Hidatsa and Arikara Nation is located on Fort Berthold Reservation on the Missouri River, spanning across six counties. The reservation itself consists of nearly one million acres, but only half are owned by Native Americans by either individual allotments or communally by the tribe. As of September 21, 2018, there are 16,165 enrolled members with over 50% between the ages of 18 and 59. Federal government policy and various Supreme Court decisions from the early 1960s and mid-1980's reflected a period of acknowledgment and support tribal sovereignty, but Congress and the courts have sought to limit the powers of tribal nations. The creation of the Garrison Dam and Lake Sakakawea has destroyed much of the economic base through inundation of farmland and urban development. The remaining land supports only limited farming and ranching. MHA was only compensated $12 million for land valued at $20 million and forced families to abandon the fertile river bottom for drier uplands. Due to the economic downward spiral, the unemployment rate is 26.5 percent leaving approximately 750 workers to support 6,000 tribal residents. Centuries of treaties have resulted in confiscation of large portions of land from the reservation and lack of economic stimulation. The implementation of the oil industry since the Bakken Boom has caused further hardship on surrounding Native American communities and their daily environment.

Impacts of Oil on MHA Tribe on Fort Berthold Reservation

A new modern-day threat has implemented itself on Native American reservations: oil boom and fracking industries. What was supposed to save their culture from despair and poverty is now destroying their land and the fragile fabric of their society. Oil rigs and pipelines have developed across land that is spiritual, poisoning the present and threatening the future. Most members within the Mandan Hidatsa Arikara tribes do not benefit from oil discovery and extraction on the reservation financially and many times suffer environmentally from this practice.

In July 2014, a million gallons of drilling saltwater spilled from a pipeline onto a steep hillside in western North Dakota on Fort Berthold Reservation. Contaminants reached a tributary of Lake Sakakawea, which provides drinking water to the community. The underground pipeline leaked 24,000 barrels of saltwater near Bear Den Bay, which flows into the Missouri River at Lake Sakakawea. This spill was only discovered when Crestwood Equity Partners were going through production loss reports, remaining unnoticed for five days. Flow traveled 1.5 miles from the location of the failure to Lake Sakakawea through a ravine with about 10,500 gallons of saltwater. Fort Berthold plays a key role in the state's oil production, manufacturing 300,000 of North Dakota's one million barrels of oil produced daily (Dept. of Mineral Resources). It is only a matter of time before a spill impacts the water as many oil rigs and pipelines are only a quarter mile from bodies of water.

current oil spill **planning**

How Pipeline Routes are Determined

The route will define the pipeline size, terrain and soil requirements. In the United States, pipeline route selection is often driven by regulations at the federal, state and local levels while considering impact on the environment. The detailed pipeline route selection starts from a broad level of search between two fixed points, a pipeline corridor. Routes are then filtered through public safety measures, pipeline integrity, environmental impact and consequences of spills based on social, economic and environmental grounds, as well as regulations and cost. The shortest route may be most cost-effective but may not be the most suitable route for various reasons listed above. Two of the most important factors that are taken into consideration is geography and the environment. Slope can present unnecessary risk for the stability of a pipeline. Often, pipelines will pass by or near communities, presenting additional concerns, such as effects of routing through farmland or water bodies. Analyzing environmentally-sensitive areas are given preference and assessment on the entire proposed pipeline route, however geography, road access, landowners and stakeholders hold a large chunk in determining what is feasible, accessible and cost effective.

Dealing with Oil Spills and Landscape Architecture Intervention

Occurrences of oil spills are unknown, whether in land or in water. Focus relies on three components of contingency planning - hazard identification, vulnerability analysis and risk assessment. Hazard identification maps oil corridors of which it travels and the industries that use large quantities of oil, extreme weather that may occur and types of oil frequently stored or transported. Vulnerability analysis researches communities and resources that could be harmed in the event of a spill, and the identification of environments that are susceptible to oil and water pollution. Risk assessment compares hazards and vulnerability in a certain location to reveal the kind of risk that is posed to a community. This plan addresses these problems to determine how to best control the spills and what can be done to repair the existing damage. A problem seen on from a landscape architecture profession is the entirety of the last statement: how to control what has already occurred and how to repair existing damage from the spill. A more ideal situation would be how to prevent contaminants from affecting vulnerable populations and environments. The best solution would be how to create resiliency in areas prone to oil extraction and transporting, instead of dealing with repercussions after an event will inevitably occur.

Landscape architects can help solve these issues and design for successful environments, specifically through improvement of GIS and hydraulic modeling. Geographic Information Systems can focus attention on locations and points of interest that are significant to a society or important for ecosystem sustainability, revealing sensitive environments and species, drinking water intakes, roads, oil storage and routes of pipelines. Through endless research and digging through to find detailed information about pipeline diameters, materials and company ownership, it is extremely difficult to obtain this knowledge. As landscape architects, making this information available to the public would allow better community planning and restoration techniques to surface. Enabling inferences to be made on where spills are most likely to occur, and the severity of the incident allows prioritization of which resources shall be protected. Having this data easily accessible makes planning and remediation strategies more effective and apt for resiliency in sensitive environments.

Typical Environmental Planning and Remediation Practices

Brownfields are abandoned, idled or underused industrial facility in which redevelopment is burned by environmental contamination, such as oil refineries and liquid storage facilities. The term brownfield originated in the early 1990s when the need for reuse, cleanup and development within the industrial environment were needed. Contamination represents the most significant public problem and the greatest barrier to putting idle property back into use. Juxtaposed against 'greenfield' – a farmland, forest or pasturelands that have never seen development – brownfields provide a sustainable land-development choice. Brownfields balance the development process so that fewer green fields are spoiled, providing regeneration for underutilized land. By estimates, the number of brownfields in the United States is near half a million, each demanding unique treatment of remediation and planning. Green infrastructure is an approach to water management that protects, restores or mimics the natural water cycle. It is effective, economical and enhances community safety and quality of life through tree planting and wetland restoration. Stormwater Management is the effort to reduce runoff of rainwater and contaminants to improve and protect water quality. When stormwater is absorbed into the soil, it is filtered and replenishes aquifers or flows into streams and rivers.

Environmental planners perform duties such as environmental inventory, site analysis and evaluation, land capacity and suitability assessment, hazard assessment and risk management for master planning. Hazard assessment specifically aims to identify dangerous zones in the environment where an ecosystem or community would be put in jeopardy of damage or destruction. Risk management entails building strategies and contingency plans to cope with hazards to provide emergency relief services. Both hazard assessment and risk management planning started gaining serious attention especially after major flooding events in the early 1990s in North Dakota with the Red River.

Water is a central factor of concern in many kinds of planning problems. A successful analysis of hydrological processes should understand the movement over and under land surface, as well as the geomorphic, geochemical and biological processes along the movement of water. The estimation of the rate and amount of runoff as overflow becomes extremely important. Currently, runoff is calculated using runoff models such as rational methods, Unit Hydrograph, SWAT, etc., which involve extensive data collection such as rainfall record, land-use, slope and topography, soil properties and runoff coefficient tables. Applying parameters like 10-year peak flow with annual runoff could help planners specify areas with intense hydrological processes to therefore, inform actions, goals and developments to achieve resiliency within communities.

technologies **introduced**

Phytotechnology

Phytoremediation uses vegetation to contain, restore or prevent contaminants from entering soils, sediments, or water sources. The plants function through three types of transfer; energy, nutrient and water transfer. Leaves transform energy from the sun via photosynthesis to generate biomass. Twenty to Forty percent of photosynthetic products are conveyed down to the root zone and leached out into the soil. Microbes process food and the 17 essential nutrients required by plants, internally. Water transfer enabling plants to act as pumps, moving water from the soil through the stems and leaves, using 10% and allowing the rest to be evapotranspired. Phytotechnology works to remediate the two types of contaminants, organic and inorganic. Organic compounds contain man-made bonds of carbon, nitrogen and oxygen, allowing them to be degraded and broken down into smaller, less toxic particles. Inorganic contaminants are naturally found elements within the periodic table, resulted from human activities such as extraction, burning of fossil fields and industrial production. Unlike organic compounds, these are elements that cannot be broken down but can rather be taken up and extracted by plants. Common organic pollutants such as petroleum hydrocarbons like oil, gas and benzene from pipe leaks or above ground storage tanks have successfully be degraded with phytotechnology.

Pollutant types easily extracted:
Plant Macronutrients: Nitrogen, Phosphorus
Source: Wastewater, agriculture
Metals: Arsenic, Nickel, Selenium, Zinc
Source: Industry, emissions

Pollutant types more difficult to extract:
Metals: Copper, Chromium, Iron, Magnesium, Lead, Mercury, Aluminum
Source: Industry, emissions
Salt: Sodium Chloride, Magnesium Chloride
Source: Fracking, oil drilling, herbicides

Implementation of Phyto Mechanisms

Through synthesis of phytotechnology and ways to remediate spill sites and sensitive ecosystems, five mechanisms have been discovered. Any or all typologies could be implemented throughout affected areas on Fort Berthold Reservation to help shield off existing and potential contaminants from entering viable ecosystems and communities. Further research has been done to define which mechanisms would be most viable within the current parameters of MHA's environment; phytodegradation, rhizodegradation, phytovolitization, phytometabolism and phytoextraction were all mechanisms that were looked at in depth as potential remediation tactics going forward.

Phytodegradation causes plants to destroy the contaminants by breaking them down into smaller particles, causing them to become less toxic to the surrounding environment and its users. Rhizodegradation uses microbes in the soil to further break down contaminants by allowing release of phytochemicals and sugars that create an environment for microbes to thrive. Phytovolitization allows the plant to release contaminants as a gaseous form by taking up the pollutant and directly transpiring it into the atmosphere. The release as a gas is slow enough that the surrounding air quality does not impact immediate ecosystem and social communities.

Phytometabolism enables the plant to use the contaminants for growth and incorporates it into biomass. This type of remediation works for plant micronutrients, such as Nitrogen, Phosphorus and Potassium, as they need to be processed and turn into plant parts. This process allows the overloading of these nutrients to be broken down. Lastly, phytoextraction for inorganic compounds such as heavy metals must be stored and then later harvested. When coupled with phytodegradation, the contaminants essentially disappear. Inorganics cannot be broken down because they are common elements found within nature but can be stored in plant shoots and leaves. Harvested plant material can be burned, followed by disposal in a landfill and later reused for biomass.

Plant Selection

The most important factor in determining success rates of phytoremediation is plant selection, specifically species with **root depth**. Since 24% of land cover is a mix of wetlands, it is essential to know root depths of species before selection and implementation. Wetland species have a root depth of less than one foot, with trees having a maximum depth of ten feet. These plants are scientifically known as **phreatophyte** plants, meaning deep-rooted and having at least part of their root system in constant touch with a water source. Plants such as Poplars and Willows can reach depths of 30 feet. Another vital characteristic is **drought-tolerance**. Species selected for this use may reach even greater depths and are often selected and preferred for phytotechnology applications. A third consideration in plant selection is ensuring biomass production.

For remediation, fast-growing plants tend to release more sugars and exudates at the root zone, creating an environment for enhanced degradation. Plants such as certain Maples, Poplars, Willows and Oaks represent phreatophyte species. A new tactic is being researched within the realm of **pioneer species**, the first to colonize in previously biodiverse-steady ecosystems. These are the first species to return after a disturbance, the first stage of plant succession and their presence within the environment produces diversity through a site or region. Pioneer species are

nitrogen-fixing plants, fast growing with high production of biomass and are often a hardy plant, algae or moss that can withstand harsh climates and hostile environments.

watershed & **flow network**

Watershed Analysis

This study uses Lake Sakakawea basin 6-digit HUC 101101) as the main study area for 4,940,539.18 Acres (figure xx). Based on 2011 National Landcover data, the basin has roughly 36% of land as Herbaceous, 44% Cultivated Crops, 3.1% Development, 2.4% wetland, 1.8% deciduous forest, 1.3% shrub/scrub. 8.5% is Open Water where Lake Sakakawea is a 307,000-acre man-made reservoir formed by Garrison Dam. Fort Berthold Reservation is located at the south end downstream of the basin which is owned by Native American as individual allotments or communally by the tribe. As of March 2016, 15013 registered tribe members were reported. This tribal land is subjected to serious threats from oil industry since North Dakota Department of Health revealed more than 8000 spills were recorded from 2008 to 2015 in the region.

Since most oils are lighter than water, they flow on top of the water. Many oil spill incidents reach and damage lakes, rivers and wetlands through the surface flow network. For example, in Jan 2015, 3 million gallons of pipeline spill have flown into nearby Blacktail creek and traveled over 27 miles reaching Missouri River. Therefore, we collected GIS data of flow network from NHDplus Dataset by EPA to represent the creeks, rivers, streams, canals, lakes, ponds etc. in the study area. This will help us locate the likely hazard and vulnerable area after oil spill incidents occurred.

Hydrological Analysis through StreamStats

Utilizing hydrological modeling using Stream Stats through the United States Geological Service has the ability to calculate flow paths based on slope and stormwater runoff rates. This software can also trace connections between two points to show areas of convergence, revealing specific areas that may be more prone to damage and contamination than others. Stream Stats can help to delineate a study area which shows all possible stream movements and will calculate a water basin within that selection regions.

Using this technology will allow analysis of set parameters within a specific basin, like percentage of prime farmland that needs protection, average slope and change in elevation, area that drains to a point on the stream, percentage of urban land, length of flow paths and soil permeability. Synthesizing all factors will help to pinpoint suitable areas of existing contamination and areas to protect from future pollution. Developed by the U.S. Geological Survey (USGS), StreamStats is a web application that provides hydrological modeling functionalities for water resources planning and management, and engineering purposes.

Drainage Basin Delineation

StreamStats provides services to delineate the watershed for a stream point of interest by integrating multiple datasets, such as the National Hydrography Dataset, the Watershed Boundary Dataset, and the 3D Elevation Program. In this study, we collected all the point of interests where the streams enter the land boundary of Fort Berthold Reservation and run all the drainage basin for these points of interests. The resulting drainage basins will show all the areas where the surface runoff flow into Fort Berthold Reservation and help identify the impacted watershed by potential Oil Pipeline Spill.

Streamflow Modeling and Hazard Identification

The other key function by StreamStats is the automatic estimation of Streamflow Statistics for each drainage basin delineated. With large amount of data from more than 25 thousand gaging stations around United States, the USGS has developed many regression equations that can be used to estimate various streamflow statistics for locations on ungaged streams throughout the Nation. As an example, the equation for estimating the 100-year flood for ungaged sites is:

$$\mathbf{Q100=5.39DA0.0874(E/1000)-1.13P1.18}$$

Where: Q100 is the peak flow that occurs, on average, once in 100 years (1-percent chance of occurrence in any year), in cubic feet per second; DA is the drainage area, in square miles; E is the mean basin elevation, in feet; and P is the mean annual precipitation, in inches.

The StreamStats will automatically detect the correct equation for the drainage basin of interests and generate flow statistics through web browser. There are also API and batch service available for requests with multiple basins (only 200 requests are allowed each time). In this study, we developed a customized StreamStats requesting script using Python to fetch all the drainage basins and its' 10-year peak flow rate in GeoJson format. Then all the results will be aggregated into a shapefile for further analysis.

Hazard Indexing and Analysis
After the hydrological analysis from StreamStats, we will be able to understand how much storm runoff will flow through each stream point on the reservation boundary at a 10-year peak event. We then estimate the overall runoff ratio at a 10-year peak event using (similar concept with Rational Method) the equation below:

$$UR10\text{-}YEAR=Q10\text{-}year/(I10\text{-}year*A)$$

Where UR10-YEAR is the runoff ratio of the 10-year peak event in the area, in percentage; Q10-year is the 10-year peak flow of the drainage basin calculated from StreamStats, in cubic ft per second; I10-year is the 10-year Peak rainfall intensity, in ft per second; A is the area of the drainage basin, in square ft.

We then ranked each stream point and traced its downstream flow network to identify the streams that oil spill will flow inside the reservation land. These down stream flow network will be seen as potential oil spill hazard for the reservation. Finally, we conducted overlay analysis and descriptive statistics of the ecosystem types being affected in the reservation.

literature **summary**

With pipeline bursts and oil spills becoming more frequent and unpredictable with the ever-growing industry, the increase in hazard and risk is increasing at alarming rates. Thousands of spills have occurred within North Dakota over the last twenty years, with 85 spills being detrimental to the social and environmental aspects of ecosystems and communities. The declination of these environments is taking place primarily within Native American Reservations, tainting soil, drinkable water sources and vital wildlife and habitat. Oil spill remediation and planning strategies are few and far between, contributing to the growing threats within the environment. Hydraulic modeling tools and analysis of basins and watersheds help to inform future design intervention to create resiliency in communities.

One gallon of wastewater can make a million gallons of freshwater undrinkable. Without proper environmental planning and execution, improper disposal of contaminants will continue to infect the ground water, damage surface soil, water resources and residents living within the industry. Research shows that only about 20% of oil compounds degrade in water, revealing 25x the level of ammonium and selenium in sampled water that the United States Environmental Protection Agency considers safe for aquatic life and use. With 8,000 miles of pipelines running through the state of North Dakota, an analysis of spill data from 2008-2015 show more than 8,000 spills were recorded with over 14 million gallons of brine documented. The expansion of the oil industry and the lack of regulations within our rogue state has enabled an average of 4.4 spills per day throughout the state since 2013.

Large spills have taken flight since the flourishing of the Bakken in 2006. This same year brought about a massive burst of one million gallons into the Yellowstone River near Alexander, causing massive die-off of fish, turtles and vegetation. The repopulation of aquatic species and the revitalization of underground aquifers remained tainted despite restoration efforts. Other spills in past years have resulted in the same degradation of the environment and its surrounding populated communities. The increased pipeline construction is allowing leaks and bursts to become more prominent throughout North Dakota.

Fort Berthold Reservation is at the brunt of these ongoing oil issues. The approximately 6,000 residents have been forced with relocation and a downward economic spiral for the past two centuries; the lack of compensation and the deconstruction of fertile agricultural land has led to hardship within their daily environment. The new modern-day threat of oil has implemented itself on Native American reservations. Oil rigs and pipelines have developed across sacred land that is now being poisoned and fragmenting the MHA Nation culture. In July 2014, a million gallons of wastewater spilled from a pipeline onto a steep hillside in Fort Berthold. Contaminants reached a tributary of Lake Sakakawea, which provides drinking water to the communities surrounding the water body.

The underground pipeline leaked 24,000 barrels of saltwater near Bear Den Ben, which flowers into the Missouri River at Lake Sakakawea. The spill remained unnoticed for five days, traveling 1.5 miles from the location of the failure to Lake Sakakawea through a ravine with about 10,500 gallons of saltwater. With pipelines and rigs placed so closely to vital waterbodies, it is only a matter of time before an outburst impacts not only the water, but those who rely on the water as a natural resource.

Pipelines will often pass by or near communities or waterbodies, presenting additional concerns of impacting wildlife, nearby residents, farmland and other vital land cover. Pipeline routes are driven by regulations at the local, state and federal levels, considering impact on the environment. From two fixed points, routes are filtered through public safety measures, potential negative effects and consequences through social, economic and environmental lenses. Cost-effectiveness and feasibility are the two most common deciding factors when placing and constructing pipelines. Focus relies on three components of contingency planning - hazard identification, vulnerability analysis and risk assessment. Hazard identification maps oil corridors of which it travels and the industries that use large quantities of oil, extreme weather that may occur and types of oil frequently stored or transported. Vulnerability analysis researches communities and resources that could be harmed in the event of a spill, and the identification of environments that are susceptible to oil and water pollution. Risk assessment compares hazards and vulnerability in a certain location to reveal the kind of risk that is posed to a community.

Landscape architects can help solve these issues and design for successful environments, specifically through improvement of GIS and hydraulic modeling. Geographic Information Systems can focus attention on locations and points of interest that are significant to a society or important for ecosystem sustainability, revealing sensitive environments and species, drinking water intakes, roads, oil storage and routes of pipelines. Having this data easily accessible makes planning and remediation strategies more effective and apt for resiliency in sensitive environments.

Phytoremediation uses vegetation to contain, restore or prevent contaminants from entering soils, sediments, or water sources. Phytotechnology works to remediate the two types of contaminants, organic and inorganic. Organic compounds contain man-made bonds of carbon, nitrogen and oxygen, allowing them to be degraded and broken down into smaller, less toxic particles. Inorganic contaminants are naturally found elements within the periodic table, resulted from human activities such as extraction, burning of fossil fields and industrial production. Unlike organic compounds, these are elements that cannot be broken down but can rather be taken up and extracted by plants.

Common organic pollutants such as petroleum hydrocarbons like oil, gas and benzene from pipe leaks or above ground storage tanks have successfully be degraded with phytotechnology. Through synthesis of phytotechnology and ways to remediate spill sites and sensitive ecosystems, five mechanisms have been discovered. Any or all typologies could be implemented throughout affected areas on Fort Berthold Reservation to help shield off existing and potential contaminants from entering viable ecosystems and communities.

Since most oils are lighter than water, they flow on top of the water. Many oil spill incidents reach and damage lakes, rivers and wetlands through the surface flow network. The collection of GIS data of flow network from NHDplus Dataset by EPA to represent the creeks, rivers, streams, canals, lakes, ponds etc. in the study area. This will help us locate the likely hazard and vulnerable areas after oil spill incidents occurred. Utilizing hydrological modeling using Stream Stats through the United States Geological Service has the ability to calculate flow paths based on slope and stormwater runoff rates. This software can also trace connections between two points to show areas of convergence, revealing specific areas that may be more prone to damage and contamination than others. Stream Stats can help to delineate a study area which shows all possible stream movements and will calculate a water basin within that selection regions. Using this technology will allow analysis of set parameters within a specific basin, like percentage of prime farmland that needs protection, average slope and change in elevation, area that drains to a point on the stream, percentage of urban land, length of flow paths and soil permeability. Synthesizing all factors will help to pinpoint suitable areas of existing contamination and areas to protect from future pollution. The ranking of each stream point and its traced downstream flow network will identify the streams oil spill flow inside the reservation land. These downstream flow networks will be seen as potential oil spill hazards for the reservation. Finally, we will conduct overlay analysis with descriptive statistics of the ecosystem types being affected in the reservation.

project **justification**

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Cultural Justification

Native Americans in the United States have been oppressed for hundreds of years, constantly confined within borders or forced to create a lifestyle in urban space away from tradition and customs. With an abundance of natural resources found within reservation boundaries, the millions of Native Americans in the United States have the highest rate of poverty of any racial group. The disintegration of tribal voice on industrialization has resulted in abuse to the natural environment. Multi-million-dollar industries undermine Native American culture, removing the strong ties between the natural landscape and spiritual values. The land that was once flourishing with sacred customs is the same land that is now infested with contaminants, revealing adverse environmental and cultural effects. Countless generations have been intoxicated through industrial invasion.

1 **Reservations contain nearly $1.5 trillion worth of the nation's natural resources**

2 **In 2016, 26.2% of single-race American Indians in poverty with a median household income of $39,719**

Biological Justification

The resistance to coexistence has led to a number of ongoing environmental issues; decreased water quality, contamination of viable soils, and loss of wildlife valuable for biological and cultural diversity. Increased application of industry has become a negative inevitable but so has the connectedness of humans to their environment. Modernism ideals have sacrificed ecosystem value for human comfort. Society has deemed human as most powerful, with the ability to alter the landscape whether for good or for bad. Forcing decline on the environment has become acceptable. Biological remediation has the ability to restore cultural values through the reclamation of presently contaminated tribal lands. Recognizing that humans are only an aspect of the landscape plays a key role in reclaiming natural resources and ecosystems. Recognizing sensitivity of ecosystem services will create harmony between the environment and those connected to it.

3 **North Dakota has 12 species listed as threatened or endangered via the Endangered Species Act**

4 **From 2013-2017, there had been 8,265 incidents, averaging to 4.4 spills per day**

Personal Justification

Growing up in North Dakota, I have experienced the on-set of the oil boom in the Bakken first-hand. I have also experienced the Native American outcries on numerous reservations through implementation of oil wells and pipelines, like the Dakota Access Pipeline on Standing Rock Reservation. Through research, I have uncovered the reality of disputes between culture and the economy showing the degradation of community values in exchange for profit. The increased number of wells and pipelines within the landscape are negatively affecting the living conditions of those on the reservation in Fort Berthold. I believe that research and design intervention can create resiliency on industry-forced communities and restore value through remediation and conservation and enhance my current academic development. In the professional realm, I feel this issue is extremely relevant. The increase extraction of oil and natural resources is altering natural and cultural landscapes throughout. The modernization of extraction is enabling an increased number of spills and contaminations, destroying ecosystems and communities alike.

5 **In 2015, 83,124 barrels of oil were spilled within the North Dakota Oil Patch**

Site Justification

In July 2014, a million gallons of drilling saltwater spilled from a pipeline onto a steep hillside in western North Dakota on Fort Berthold Reservation. Contaminants reached a tributary of Lake Sakakawea, which provides drinking water to the community. The **underground pipeline leaked 24,000 barrels of saltwater near Bear Den Bay**, which flows into the Missouri River at Lake Sakakawea. This spill was only discovered when Crestwood Equity Partners were going through production loss reports, remaining unnoticed for five days. Flow traveled 1.5 miles from the location of the failure to Lake Sakakawea through a ravine with about 10,500 gallons of saltwater.

Fort Berthold plays a key role in the state's oil production, manufacturing 300,000 of North Dakota's one million barrels of oil produced daily (Dept. of Mineral Resources). It is only a matter of time before a spill impacts the water as many oil rigs and pipelines are only a quarter mile from bodies of water.


WHITE LODGE

historical, social & cultural **context**

How does the project relate to similar projects undertaken throughout history?

This project doesn't necessarily relate to other undertaken projects throughout history, but there have been many instances of Native American displacement due to industry on reservations. Industry has tainted much of the land, causing environmental and psychological hardships on Native American culture. Many times, the problem of people and industry has been solved by eviction. Imagine relying on your land as a source of food. Then one day the government advises you against your way of life because a multi million-dollar organization polluted the water, land, agriculture and wildlife with poisonous toxins. How would you adapt to this? Do you change your entire lifestyle overnight? Do you ask for help from the very people who diminished your people's way of life for hundreds of years? Or do you simply ask them to take action and leave you alone?

How does this project relate to social trends or developments within our society?

Native American customs and traditions honor the land they lived off for countless generations. That same land is not riddled with toxins and contaminants which they had no part in polluting, and yet they face some of the worst adverse effects of its presence. Lack of opportunity within an array of domestic issues set on by the federal government, and high poverty rates present many Native Americans from achieving a quality of life many other non-Native Americans are used to.

Although based in Washington, the Yakama Nation says toxic contamination from the Superfund site has managed to spread downstream into the Willamette River and further into the Columbia River in Washington. The Yakama rely heavily on the ecosystem of the Columbia River to provide them with water and fish – both of which are now contaminated – to provide for the needs of over 30,000 people living in the Yakama reservation.

Inuit people in Canada and the Arctic maintain not only a diet, but a lifestyle of customs and traditions which they have maintained for thousands of years before European settlers began colonizing the Americas. Along with PCBs, Inuit are also at a higher risk of exposure to heavy metals such as mercury, as well as dioxins, DDTs and other Persistent Organic Pollutants (POPs) – not only through their diet but simply from residing in the Arctic. Arctic Inuit fear that the contamination affecting them is forcibly changing their way of life. If the Inuit must be forced to rapidly change their diet, millennium old hunting practices will begin to phase out of Inuit culture, impacting their internal trading customs and likely causing a new array of health defects. If the Inuit cannot hunt it's only a matter of time before their new way of life becomes sedentary. The Arctic Circle was once considered one of the world's last pristine natural reserves, untouched by man. Now our studies and sciences show it has become a forum for deadly toxins and contaminants more immense than any seen before in nature.

These are just a few of many examples of cultural shifting due to environmental degradation. When land becomes contaminated and unsuitable for life, those living in those environments must react and conform to new lifestyles.

Perhaps a more contemporary example of possible contamination facing Native American tribes is that of the Dakota Access Pipeline (DAPL). Heavy protests spawned during the construction of DAPL in South Dakota attracting international attention and, at their peak, roughly 10,000 protesters including celebrities, environmental activists and politicians. The protests also saw what may be the largest-ever recorded coming together of native tribes and people in the United States. Protesters argued against DAPL's construction, citing that portions of its planned route disturbed sacred indigenous sites of extreme cultural importance including burial grounds. Those in favor reported claims that DAPL would become the nation's safest method of transporting crude oil from North Dakota to Illinois rather than having to ship barrels of oil at a time to refineries. Another key argument against the pipeline's construction was the likelihood of spills which could contaminate surrounding soil and drinking water with crude oil. Sure enough, DAPL leaked no less than five times in 2017 after its construction with spills ranging from 21 gallons at a pump station to 168 gallons near its endpoint in Illinois.

Dakota Access Pipeline Protest

What is the physical and social context within which your project is set?
The integration of the Mandan, Hidatsa and Arikara into the Three Affiliated Tribes occurred in 1823 and the Bureau of Indian Affairs (BIA) was established one year later. Over the span of the next 50 years, Native Americans were forced into assimilation, attending boarding schools on the east coast and losing their original names completely. The onset of the Civil War pushed tribes westward onto the plains of the Upper Missouri, repeatedly being attacked by the military and the Sioux. Fort Berthold and the surrounding villages were burned by raids and the government moved the fort eastward. The Treaty of Fort Laramie in 1851 designated 12.5 million acres of reservation lands between the Yellowstone and Missouri rivers - later reduced to a mere 640,000 acres by 1910.

By 1880, after suffering land losses during the Civil War time frame, lose the southern half of Fort Berthold reservation so the United States can fulfill a grant made by Congress to the Northern Railway. It wasn't until 1884 when the first allotments were made to tribal members only to have the MHA tribe lose titles to the land lying north of the 48th parallel two years later.

1887 Dawes Act is passed authorizing the President to survey Native American tribal land and divide it into allotments for individual Native Americans. Those who accepted allotments and lived separately from the tribe would be granted United States citizenship

1910 Homestead Act is passed and Congress opens 21 full and partial townships for homesteading without tribe's approval

The mid-1940s brought about more unrest and injustice within Fort Berthold and the MHA tribe. Construction of the Garrison Dam was being protested by tribal members and farmers who would be affected, creating material that showcased the negative aspects of the dam. In 1944, Congress created a "Plan for the Development of the Missouri River Basin" without Native American input under Lewis A. Pick and W. Glenn Sloan. Under this plan, suitable areas for dam construction were considered, amongst opposition. Ultimately, support of Indian opposition forced the Pick-Sloan Plan and the taking of tribal lands for promised flood control for surrounding predominately white communities. In the 1950s, the completion of the dam became an unavoidable reality within the reservation, impacting communities who were now forced to regroup and relocate after past removals from the bottomlands.

As a consequence of the project, the newly recovered tribal economy was destroyed – still felt through contemporary Indian actions and communities. More than 90 percent of the population was relocated to accommodate the dam, impacting the health, housing and social interaction within Fort Berthold. The 1951 population consisted of 356 families on 583,000 acres, relocated. The loss of agriculturally-rich lands altered their way of life of self-sufficiency. The toll on the Native American economy was severe; the floodplain timber that provided logs for housing, fence pots and natural cover for wintering livestock, the wild fruits and berries, and the game that supplemented the food supply. Water supplies were replaced by drilled wells that have since proven inadequate and dangerous for drinking.

"On the river bottom we had plenty of water to drink, wash and water our livestock. When we were forced to move to the upper plains, wells were dug so deep that you could not pump them by hand...When we moved to the prairie, we could no longer eat the chicken eggs...they were blood red because of the water! The water was not suitable even for animals."

Displacement disrupted cultural beliefs and practices, relocating cemeteries and shrines largely associated with Christian churches and monuments. Native American sacred religious structures, and clan burial sites where skulls were placed in circular form to mark clan cohesion, not then protected by the Indian Religious Freedom Act and the National Historic Preservation Act, were submerged under the floodgates of the Garrison Dam. Nearly 155,000 acres of good farmland were permanently under water. Final relocation was completed by 1955, with a declination in the standard of living by 1960. Housing standards decreased further within the next twenty years, with 87 percent of homes lacking a safe, sanitary method to refuse disposal and 81 percent of people carrying water a half-mile or more. These conditions have caused conflicts between traditional and contemporary values within Native American culture of physical distress and psychological issues. Diverted profits are the result of industrial intervention, where revenue is exported away from the reservation and re-invested in non-Indian business ventures.

Construction of the Garrison Dam

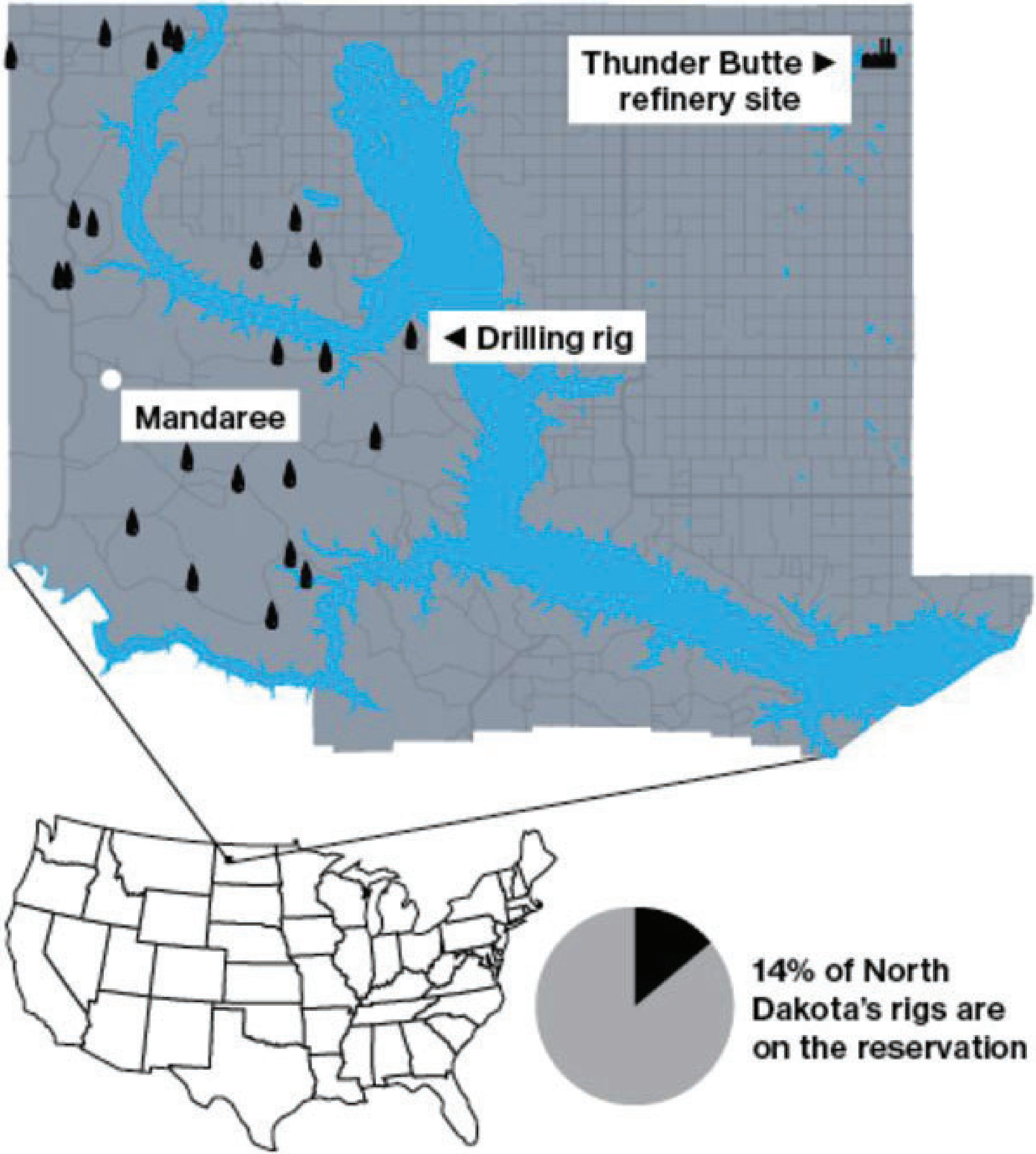
Lake Sakakawea was created as a result of the Garrison Dam gates being closed in 1956. Water started flowing over into the reservation, making it the largest body of water in North Dakota and the third largest man-made lake in the United States. Sakakawea is almost 200 miles long, ranging from 1 to 14 miles wide. With the implementation of this water body, some residents moved off the reservation and others constructed new towns to replace the ones that had been destroyed. Mandaree, Twin Buttes and White Shield were placed on the east and west sides of the lake.

Beginning in 1910, several small oil wells were drilled in North Dakota. These wells however, produced little to no oil because drillers did not drill in the right place or deep enough. The first major discovery of petroleum in ND was in 1951, in a wheat field near Tioga, in Williams County. From 1951-1980 this field produced more than 585,000 barrels of oil.

An oil boom took place in ND in the late 1970s and early 1980s. In 1984, the boom peaked at 154,000 barrels per day at an average price of $35bbl. In the mid-1980s, the boom turned bust. World oil prices plummeted to $10 per barrel in 1985. Only three wells out of every 10 were producing. Oil drilling continued into the 1980s and 1990s using horizontal drilling. By 1990, the price of oil had increase, but extraction from the deep shale rock was not as efficient or profitable as it would become with advanced drilling technology. Around 2000, a major oil boom began in the Bakken Formation. New extended reach horizontal drilling made it profitable for oil companies to extract oil and gas from shale rock. Made it possible for oil companies to drill down two miles and then angle horizontally for another 2-3 miles. The Bakken has become one of the most important sources of oil in the United States. North Dakota is now the second largest oil producer. In June 2014, North Dakota's oil production hit the milestone of 1 million barrels of oil per day.

Oil Extraction on Fort Berthold Reservation

Today, MHA Nation has filed a lawsuit against the U.S. Department of Interior as they continue to challenge the oil wells that are believed to be drilled too close to Lake Sakakawea. Due to tribal regulations being overlooked, the Bureau of Land Management (BLM) approved oil well drilling. Slawson Exploration Company has drilled and proposed to drill 23 oil wells near New Town with hydraulic fracturing in the works. The continued oil extraction threatens the reservation's primary source of drinking water as well as critical natural, cultural and recreational space. Regulations state that wells must be located at least 1000 feet from Lake Sakakawea but are currently placed within 600 feet. Horizontal wells will extend anywhere from 2.5 to 3 miles beneath Lake Sakakawea to develop federal, state and private minerals. The wells on site will be transported by pipelines, creating more impacted areas in case of breaks or spills.



Drilling on Fort Berthold

site **analysis**

Recreation on Lake Sakakawea

Fishing remains the primary recreational activity on Lake Sakakawea, offering a wide-range of fish species such as pike, walleye, and Chinook salmon. Ways of access include boat ramps and shoreline areas. The extension and implementation of boat ramps eliminate congestion in recreational and wildlife management areas. Shoreline access areas are located around the lake, allowing additional means of water access during times of low water on Lake Sakakawea.

Fishing Times & Locations

Walleye

May: Upstream from the Four Bears Bridge
June: Van Hook, Snake Creek, Garrison Dam
July: Van Hook to the Four Bears Bridge
Winter: Upstream from the Four Bears Bridge

Small-Mouth Bass

June-August: Garrison Dam to the Little Missouri Arm

Northern Pike

Spring: Upper ends of all the large bays

Salmon

August-October: Face of Garrison Dam
August-September: Boat fishing
October: Shore fishing

Trout ssp.

Year Round: Garrison Dam Trailrace

Catfish

Year Round: Garrison Dam Trailrace

Lake Sakakawea is a reservoir on the Missouri River, containing 32% of all water into the Missouri River system. It was created in 1956 after the implementation of the Garrison Dam and is the third largest reservoir in the United States.

Regional
180 miles long
1,530 miles of shoreline
180 feet deep at Garrison Dam
382,000 acres - surface

Fort Berthold
155,000 acres
of reservation land
600 miles
of reservation shoreland

Land Base

Fort Berthold Reservation is located in western North Dakota, occupying sections of six counties: Mountrail, McLean, Dunn, McKenzie, Mercer and Ward. The total area of the reservation is approximately one million acres, one-half being trust land. Lake Sakakawea covered 155,000 acres of reservation land and 600 miles of reservation shoreline.

Reservation Acreage: 980,000 acres
Individual Allotment: 356,998 acres
Returned Homestead Area: 353,790 acres

Topography & Climate

Located on the western edge of the Missouri Coteau, topography of this area was formed by glaciers shaped in the lake Cretaceous Period and further shaped by erosion. The Missouri Coteau separates the Central Lowlands of North Dakota on the east from the Great Plains on the west. The eastern portion of Fort Berthold resembles the Great Plains and showcases rolling hills and valleys. The western side of the reservation consists of rolling uplands, large hills and buttes, and well-developed valleys and badlands.

Precipitation ranges from 14-16 inches with most falling during the growing season, preventing drought. Summer rain is primarily from thunderstorms which develop suddenly and intense within this part of the country. The west segments of the reservation are used primarily for livestock production. The north, east and northeast segments are comprised of rolling grasslands, used for agricultural purposes. The average number of growing days ranges from 110-119 days with approximately 130-139 days of 28-degree temperatures or above.

Vegetation

Plantings within the western and southern segments of Fort Berthold Reservation are mainly grass types; Western Wheat Grass, Little Bluestem, Blue Grama, Needlegrass, etc. In the gullies, berries are produced from June Berry, Buffalo Berry, and Choke Cherry which are all-natural food sources of the reservation. Predominate tree species consist of Bur Oak, Green Ash and Cottonwood.

Western Wheatgrass | pascopyrum smithii

Use: Used for erosion control, excellent because of its spreading rhizomes. Used for range seeding, revegetation of saline and alkaline areas. For livestock, Western Wheatgrass provides high quality forage for pasture and range. Adaptable to a wide variety of soils, tolerant of spring flooding, high water tables and silt deposition. Palatable to cattle more than sheep, with quality diminishing in the summer. If treated with nitrogen, it will compete with warm season grasses.

Little Bluestem | schizachyrium scoparium

Use: Used for pastures and rangelands and in prairie restoration. This species provides good forage while young for cattle and horses, but too coarse for goats and sheep. Little bluestem has been used extensively in prairie restoration projects because of its adaptation to a diversity of site conditions like drought, growth habit and wildlife appeal. This species can form mats from its short rhizomes on wetter sites, providing areas of erosion control. Little Bluestem is one of the best grasses for nesting habitats for upland game birds, finches and tree sparrows. The seeds provide a food source for birds that spend the winter on grasslands like prairie chickens and grouse.

Ethnobotany: Dried leaves and stems were rubbed into soft fiber for moccasin lining and insulation.

Bur Oak | Quercus macrocarpa

Use: Medium to large-sized tree, growing typical up to 80 feet in height. The acorns are eaten by many birds, squirrels, rabbits, deer, turkey and wood ducks. Bur oak is browsed by deer, elk, moose and cattle. Bur Oaks are helpful in restoration of degraded sites and have been widely planted in windbreak and shelterbelt systems because of their drought tolerance with a deep tap root. This species is also commonly used in riparian forest plantings. Bur Oak has declined on savannas and prairies due to grazing and fire management. It is not resistant to flooding, surviving saturated soils for 30 consecutive days. However, this species is tolerant of high salt.

Ethnobotany: Native Americans used the inner bark to treat various maladies such as cramps, wounds and sores, heart and lung trouble, and insect bites. The large acorns found within the tree were roasted in

Cottonwood | Populus deltoides

Use: Cottonwoods are planted contaminated soils and are quick growing to provide shade in riparian and recreational areas. Species best growth is on moist, sandy loam or silt loams, tolerating soil pH ranges from 4.5-8.0. Cottonwoods have been found to be tolerant of dry sites but are also resistant to flood damage.

Green Ash | Fraxinus pennsylvanica

Ash trees are one of the most valuable and abundant North American woodland trees, ranging from 7-9 billion. After the onset of Dutch Elm Disease, green ash was being heavily used as a replacement for the American Elm, however, EAB is quickly spreading across the Midwest. Emerald Ash Borer (EAB) was first discovered in Detroit in 2002, believed to have entered the country on a wooden packing materials shipment from China. Since then, this insect has destroyed tens of millions throughout the states. Small trees can die as soon as one to two years after infestation, while larger infested trees can survive for three to four years before mortality.

More than 30% of North Dakota conservation plantings are made up of green ash through shelterbelts. Green ash comprises more than 60% of natural riparian forests throughout the state. Many North Dakota communities have over 65% green ash within boulevards and other sites. Drastic habitat change in natural forest areas and riparian areas are expected to negatively impact water quality and aquatic life due to the loss of canopy density. Major decline in conservation and crop protection due to loss of shelterbelts is expected.

Fort Berthold Demographics

The flooding of the rich agricultural lands destroyed the Native American population centers within Fort Berthold Reservation. After the implementation of the Garrison Dam and Lake Sakakawea, communities moved upland and were spread thin throughout the reservation. American Indians are the largest minority population in North Dakota. Census data reveals growth in population (12%) from 35,228 in 2000 to 39,525 in 2008. As of 2015, American Indian population in North Dakota reached 47,000 and is expected to increase to 59,000 in 2025.

2010 Census: 6,341
2010 American Indians on Fort Berthold Reservation: 4,556 or 71.8%
2016 Tribe Enrollment: 15,013
Unemployment Rate: 42.0%
Median Age: 29.5
Median Household Income: $35,288 -McKenzie County
Individuals Below Poverty Level: 43.2% -McKenzie County
Total Youth Population: 2,441
Total 65+ Population: 618
People per Square Mile: 10.6

Major Town Demographics

Mandaree

Population: 739 (2016 Census)
Median Household Income: $28,333
Poverty Rate: 59.5%

New Town

Population: 2,528 (2017 Census)
Median Household Income: $54,038

Parshall

Population: 1,250 (2017 Census)
Median Household Income: $59,432
Poverty Rate: 16.5%

White Shield

Population: 359 (2016 Census)
Median Household Income: $44,375
Poverty Rate: 26.9%

Four Bears Village

Population: 577 (2016 Census)
Median Household Income: $48,906
Poverty Rate: 36.7%


Four Bears Village Aerial


Near Mandaree, ND


New Town Aerial


Historic Site in Parshall, ND

Land Cover

Northwestern Great Plains Shrubland

This ecological system ranges on fine to sandy loam soils and may be located along upper terraces of rivers and streams, with gentle slopes and upload sandy loam areas throughout its range. Shrubland contains greater than 10% grassland cover with breaks of natural shrub species. These ecosystems form from Mixedgrass prairies from fire suppression, where greater shrub species was a result.

Bur Oak Forest and Woodland

Dry-mesic forests occur on upper slopes of bedrock bluffs. Landscape setting is mainly loess-covered bedrock hills. Parent material is wind-deposited silt deeper than 30 inches. The silt is typically stoneless with dark horizons, indicating former occupation of these sites by oak or aspen woodlands. Soils are well-drained.

Ground-layer: cover varies from patchy to continuous (25-100%)

Shrub-layer: cover is patchy to interrupted (25-75%) such as pagoda dogwood, american hazelnut and chokecherry

Subcanopy: cover is patchy to interrupted (25-75%); important species include cottonwood, black cherry, northern red oak & white oak

Canopy: cover is interrupted to continuous (50-100%); the most common species are white oak, northern red oak and cotton wood.

Western Great Plains Wooded Draw & Ravine

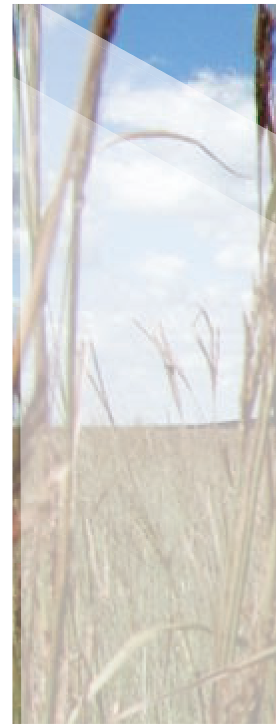
This ecological system occurs in major tributaries and upland drainages, with vegetation best developed in topographic conditions that favor protection from fires in adjacent grasslands. These systems are greatly impacted by topography, which influence deep soils, moisture and run-off. A mix of western grassland and shrubland species with elements of deciduous woodlands, with high density of quaking aspen.


Great Plains Badlands


Bur Oak Forest


Wooded Draw & Ravine

Northwestern Great Plains Mixedgrass Prairie
Soil texture is the defining environmental descriptor; primarily fine and medium-textured. This system occurs on a wide variety of landforms. Found in the Western Great Plains north of the shortgrass prairie and west of the tallgrass prairie. Due to its proximity to other prairie types, this system contains elements of short and tallgrass. The cooler climate in this region allows natural cool-season grasses to be more vital (greater than 50%). Cover of native, nongrazing-induced shrubs typically does not exceed 25%.

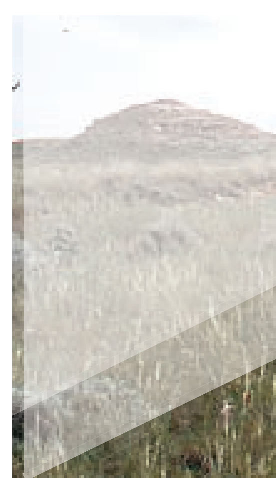


Western Great Plains Tallgrass Prairie
This system is found in areas where soil characteristics allow for sustainability of tallgrass species. It is generally small patches dispersed throughout the Northwestern Great Plains Mixedgrass Prairie or Western Great Plains Shortgrass Prairie. Tallgrass prairies are generally found in upland terraces about floodplain systems where mesic conditions are present. Big and Little Bluestem and Western Wheatgrass is dominate within these regions as well as forbs in varying density. Fire suppression within these ecosystems has allowed woody plants to invade. Grazing has also contributed to quality decrease of this system.

Prairie Grasslands are now considered North America's most endangered ecosystems:

99% decline in tallgrass prairie
68% decline in mixed-grass prairie

Western Great Plains Depressional Wetland Systems
The emergent marsh ecological system is composed of lowland depressions and along lake borders that have open basins and a permanent water source throughout the year. These areas are distinct and have a large watershed of significant connection to the groundwater table. Submergent and emergent marshes are present, as well as wet meadows and prairies. Theses ecosystem communities are spread throughout the Western Great Plains in the shortgrass regions.



Western Great Plains Badlands
The badlands system is typified by extremely dry and easily eroded, made up of clay soils with bands of sandstone with little to no vegetative cover. In areas with vegetation, species can include scattered individuals of many dryland shrubs or herbaceous material. Western Great Plains Badlands occur where land lies well above its local base level, created by elevation, rainfall, the carving of streams and parent material. Vegetation cover ranges from less than 10% to as high as 20%.

performance **criteria**

The most challenging aspect of performance criteria of a remediation and community planning system is the large planning scale and the post-management within Fort Berthold Reservation. However, this project is extremely vital due to the impacts it will have on its surrounding ecosystems and community culture that have been and continue to be impacted by the oil industry. Final design intervention will pinpoint vulnerable areas that are needed for immediate protection, environmentally and socially to provide a sustainable community for the MHA tribe. The most significant aspects of the performance criteria will be environmental performance through hydraulic modeling and stream stats, designing based on code and culture to determine site success.

1 Space Allocations

The site will have an array of space allocations that will allow ample area of environmental and ecosystem restoration to take place. Space allocations for this design segment will come from case study research of similar remediation projects which are relative in typology or size. Currently, there is very little remediation being done with oil spills making this a vital topic of exploration and implementation. Community planning within the major MHA tribal communities need to follow code compliance for land use, creating an armature effect that can protect residents from the interrogation of oil within their land. Space allocations will include:

Remediation Zones
Plant Spacing Required for Prime Contaminant Uptake
Housing Codes
Greenspace Requirements

2 Energy Consumption

With remediation and sustainability being the focus of my design, energy consumption is vital within the final product of design intervention. I will be utilizing Zero Energy Modeling throughout my research and site design. It is important that Native American communities can sustain and thrive on zero energy ways of life, away from the need of natural gas, oil or coal, non-renewable resources that have tainted sacred land through industry. Zero Energy Modeling will be essential for:

Tree Selection & Contaminant Uptake
Nutrient Uptake
Zero Energy Housing

3 Environmental Performance

It is important that sustainable materials are used to achieve the best design results, through remediation and land conservation. Through research and hydrologic modeling, I will be able to acquire land segments that are in need of desperate protection and restoration and determine which plants would be most successful in certain areas of intervention. Performance regarding natives and non-natives will be important in determining the success of ecosystems and its services. It is important that non-natives do not out-compete and rather help to flourish its surrounding environment. Research on phyto-remediative plants will be important during plant selection and determining what trees, shrubs and grasses perform in specific soils types and contaminant zones.

4 Behavioral Performance

The behavioral performance criteria is directly related to space allocations and will be determined by spatial distributions during the design phase. This will also be determined by the conclusion of research on community planning within Native American communities and how to effectively implement culture and industry space cohesively and non-destructively. Ultimately, this will determine the success of its people and their environment on Fort Berthold reservation and contribute to the present-day lack of safety on site.

5 Psychological Performance

Research on remediation and the impact of community values will directly correlate to the psychological impact. By researching off-grid housing and communities by protecting sacred land within the reservation, I can help implement models that will serve as barriers to help MHA culture thrive. In the end, the psychological impact of remediation and thoughtful community planning will help residents within Fort Berthold feel secure and safe within their community that is presently ridden with toxins.

6 Environmental Impact

The performance criteria of environmental impact is related to the damage that oil has contributed within the reservation. Utilizing NEPA standards to ensure industry is doing all it can to mitigate cultural and environmental damage within Fort Berthold will be vital in producing a safe community. Again, utilizing water modeling will help determine suitable sites for intervention and conservation.

7 Code Compliance

I will be utilizing codes set in place by the federal government and the tribe itself to determine community development codes. I hope to reach out to firms and other professors at NDSU that are currently working with Zero Energy initiatives on Native American reservations such as Dominic Fischer and Malini Srivastava, that can help me improve my research and design standards as the semester progresses.

8 Cost

Using a large existing site, cost will be difficult to manage. Remediation is an expensive design tool, yet it is necessary in order to sustain ecosystems and surrounding communities within Fort Berthold. Money will need to be invested within vulnerable sites to further restore and protect. Through research of material and plant cost, I am hoping to find a range of what types of phytoremediation techniques can be successfully implemented and maintained under a government budget.

Additional Performance Criteria

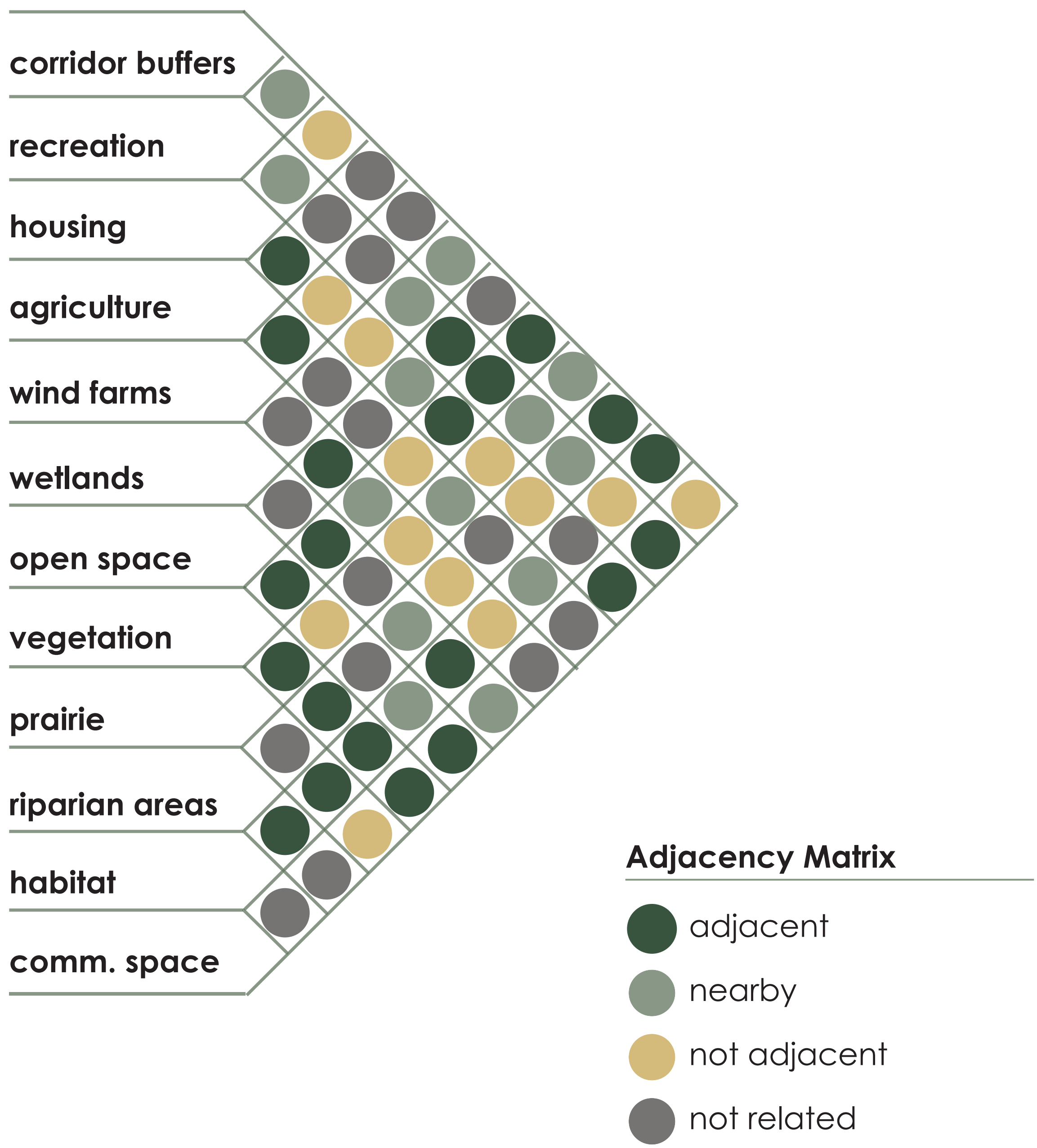
Ecosystem Types Protected
Size of Protected Ecosystems
Length of Intersecting Pipelines
New Habitat Created
Expected Pollution Remediation
Cost-Saving through Remediation
Acreage of Protected Farmland
Speed of Planting Establishment
Cost of Planting Maintenance

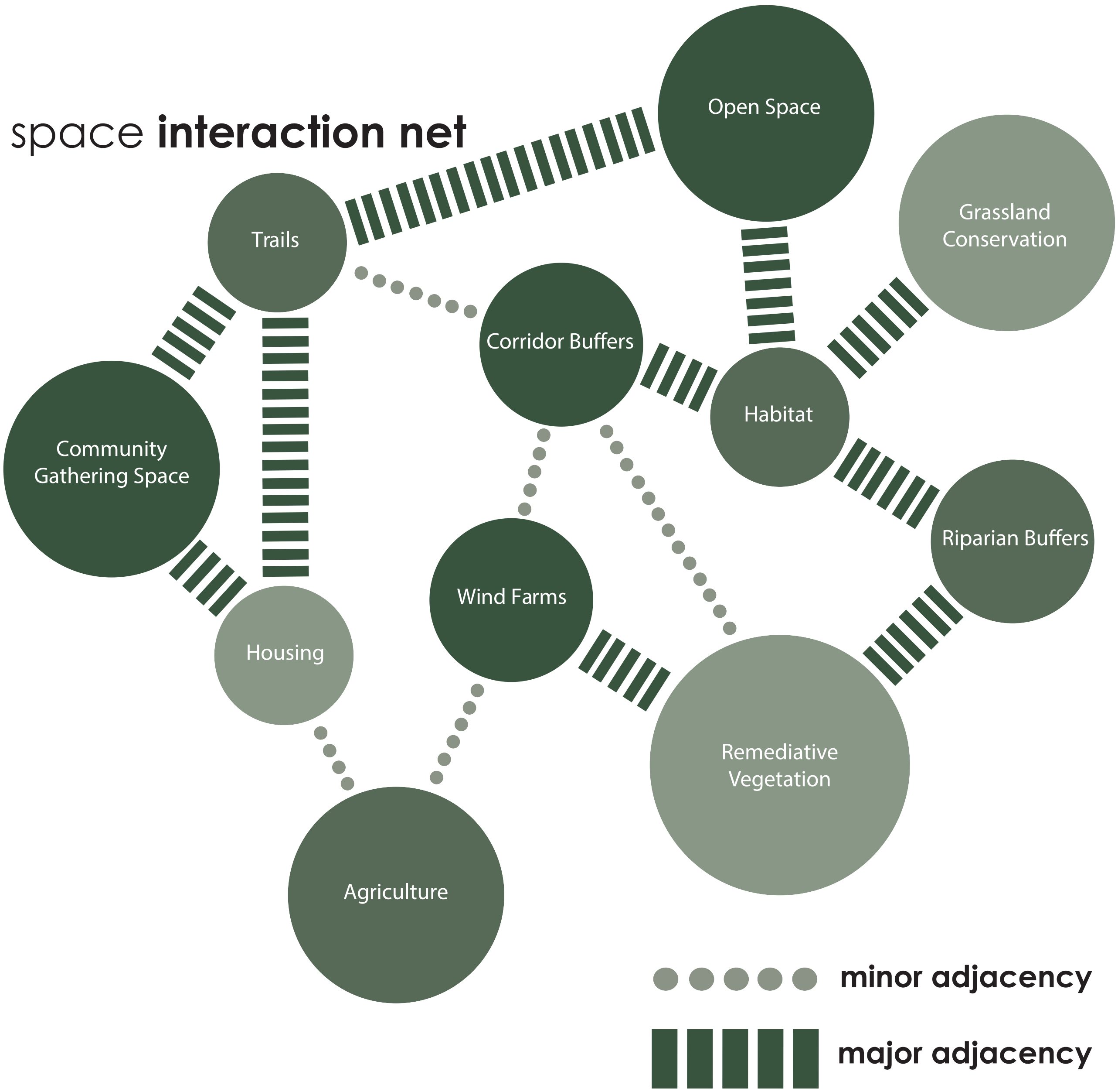
Impacted Watershed Basins
within Fort Berthold Reservation

orderNumber	Mean Basin Slope from 10m DEM	Length of longest flow path	Ag Land Percentage	Mean Basin Elevation	Stream Length Total (Mile)	Drainage Area (Square Mile)	Average Soil Permeability (inches per hour)	Average percentage of impervious area determined from NLCD 2011 impervious dataset
1	11.21	22.99	14.29	2326.30	105.20	48.76	1.54	0.23
2	8.26	16.43	32.78	2327.61	45.08	22.27	1.93	0.34
3	9.21	12.60	24.90	2301.87	63.31	24.34	1.92	0.45
4	4.69	0.60	39.89	2306.45	0.26	0.13	0.94	0.68
5	6.47	2.28	17.75	2297.24	2.61	1.31	1.15	0.25
6	7.64	1.10	0.00	2317.39	0.73	0.38	0.97	0.00
7	8.37	0.86	0.00	2341.88	0.52	0.21	1.04	0.33
8	9.71	1.91	0.00	2331.75	3.73	1.00	1.18	0.10
9	17.79	4.71	0.82	2340.38	16.71	5.79	1.92	0.08
10	11.03	8.18	20.46	2349.33	21.47	8.84	1.96	0.35
11	9.59	3.51	26.37	2282.33	3.14	1.69	1.60	0.60
12	8.07	9.44	38.83	2286.95	30.22	13.69	1.46	0.37
13	5.21	12.52	45.14	2204.57	36.55	23.30	3.26	0.44
14	4.01	42.97	57.56	2121.63	244.07	211.44	3.64	0.26
Average	8.66	10.01	22.77	2295.41	40.97	25.94	1.75	0.32

spatial **programming**

Spatial programming is an essential part of the design process. This type of programming varies widely from typology to typology, and proves to be very effective in the analysis and planning sectors of landscape architecture. By further diagramming future elements and connecting the existing, I am able to draw conclusions as to what intervention is needed and what should be added to make Fort Berthold's vulnerable areas resilient.





Plant Selection for Petroleum Uptake

Species	Type	Hardiness	Native Range
Norway Maple	Decidous	3-7	Europe
Western Wheat Grass	Grass	3+	Asia
European White Birch	Deciduous	3--6	Europe
Sideoats Grama	Grass	3-9	North America
Buffalograss	Grass	3-9	North America
Eastern Red Bud	Dedicuous	4-9	United States
Eastern Red Cedar	Conifer	2-9	United States
Fabaceae ssp.	Deciduous	varies	varies
Meadow Fescue	Grass	3-9	Europe
White Mulberry	Deciduous	3-9	China
Black Hills Spruce	Conifer	2-6	United States
Jack Pine	Conifer	3-8	North America
Scots Pine	Conifer	3-8	Europe
Kentucky Bluegrass	Grass	3-8	Europe
Populus ssp.	Deciduous	varies	varies

Appendix

"There are only so many times you can insult the earth and still continue to live on its surface..."

-Biron Baker, M.D., Tribal Doctor

important **resources:**

Marsh, W. M. (2010). Landscape planning : environmental applications. Hoboken, NJ: Wiley.

Dunne, T., & Leopold, L. B. (1978). Water in environmental planning. W.H. Freeman.

Sitterson, J., Knightes, C., Parmar, R., Wolfe, K., Muche, M., & Avant, B. (2017). An Overview of Rainfall-Runoff Model Types. U.S. Environmental Protection Agency

Three Affiliated - Demographics - Land Base and Land Status (August 1, 2016). Retrieved from ww.ndstudies.org.
Demographics | North Dakota Studies (August 1, 2016). Retrieved from ndstudies.gov.

Oil Program Center. (1999). Understanding Oil Spills And Oil Spill Response. U.S. Environmental Protection Agency

Cozzarelli, I. M., Skalak, K. J., Kent, D. B., Engle, M. A., Benthem, A., Mumford, A. C., … Jolly, G. D. (2017). Environmental signatures and effects of an oil and gas wastewater spill in the Williston Basin, North Dakota. Science of The Total Environment, 579, 1781–1793. https://doi.org/10.1016/J.SCITOTENV.2016.11.157

Kernell G. Ries, Guthrie, J. G., Rea, A. H., Steeves, P. A., & Stewart, D. W. (2008).StreamStats: A water resources web application. Fact Sheet. https://doi.org/10.3133/FS20083067

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Berenbrock, C. (2002). Estimating the magnitude of peak flows at selected recurrence intervals for streams in Idaho. U.S Geological Survey Water-Resources Investigations Report 02-4170, 59 p.

Cozzarelli, I. M., Skalak, K. J., Kent, D. B., Engle, M. A., Benthem, A., Mumford, A. C., … Jolly, G. D. (2017). Environmental signatures and effects of an oil and gas wastewater spill in the Williston Basin, North Dakota. Science of The Total Environment, 579, 1781–1793. https://doi.org/10.1016/J.SCITOTENV.2016.11.157

David, K. (2016). North Dakota’s Oil Spill Record: 85 Pipeline Accidents in 20 Years. TakePart, . Retrieved from http://www.takepart.com/article/2016/12/08/north-dakotas-oil-spill-record-86-pipeline-accidents-20-years

Design Tools to Utilize:
- Research and development: Hand drawing, sketching and modeling
Microsoft programs for studies and data collection
ArcGIS for site data analysis

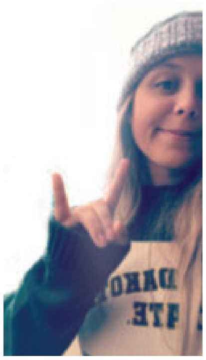
-Digital Modeling Software: Sketchup, AutoCad, Rhino
- Rendering Software: VRay, Lumion, Enscape
- Graphic Programs: Photoshop, Illustrator, InDesign, Acrobat
- Physical Modeling Tools: Laser cutter, hand tools, CNC

Case Study Sources:
www.asla.org
www.mvvainc.com
www.cclr.org
www.asla.org/2018studentawards

Site Resources:
ecospears.com
harveymjacobs.com
insideclimatenews.org
streamstats.usgs.gov
northdakotapipelines.com
huffingtonpost.com
3generations.org
dmr.nd.gov
http://indianaffairs.nd.gov/statistics/
USDA PLANTS
US Army Corps of Engineers
ndstudies.gov

Other Sources:
Land Mosaics
Phyto

the **author:**



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morgan.daviskollma.1@ndsu.edu

studio **experience:**

Second Year

Fall 2015
Kathleen Pepple
Tea House; Moorhead, MN
South Pleasant Church; Christine, ND

Spring 2016
Dominic Fischer
20 Below Alley; Fargo, ND
William Marshall Park; Winnipeg, MB
Riverfront Park; Fargo, ND

Third Year

Fall 2016
Matthew Kirkwood
Veteran's Home; Lisbon, ND
Graffiti Park; Eagle Butte, SD

Spring 2017
Paul Gleye
International Design Studio
Simon Bolivar Canal
Brussels, Belgium

Fourth Year

Fall 2017
Jason Kost
Public Transit Study; San Francisco, CA
Abstract Modeling; Copenhagen, DK
Retail Corridor; San Francisco, CA

Spring 2018
Yang Song
Community Planning; Ortonville, MN
Diversion Wildlife Crossing; Fargo, ND
Equestrian Trails; Devils Lake, ND

Fifth Year

Fall 2018
Yang Song
Red River Environmental Planning
Fargo, ND

Spring 2019
Jason Kost
Ecological & Conservation Planning
Fort Berthold Reservation, ND

Professional Practice

Summer 2017
Land Elements Fargo, ND
Landscape Designer Intern

Summer 2018
Contour Design Studio Fargo, ND
Landscape Designer Intern

"In the midst of all this chaos I wouldn't want to be anywhere else...this is where my people were a long time ago."

-MHA member JayLi Fimbres


"Now's the time to rebuild our economy and our future. In 25 years, our children must have a place to live. We'll never be vastly rich, but we can raise the standard for everyone and leave no one behind if we manage it properly."
-Mark Fox, Chairman